Instruments

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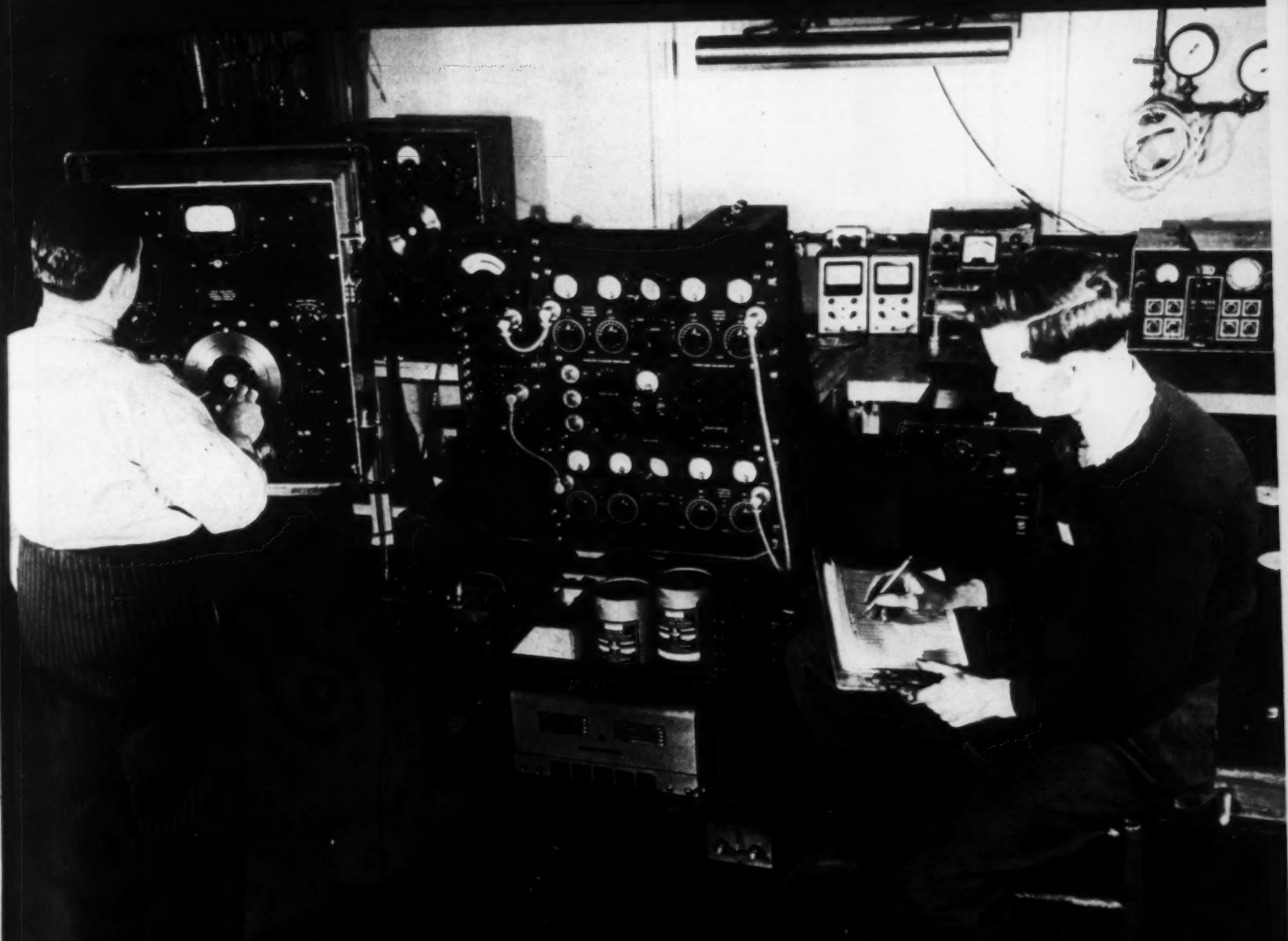

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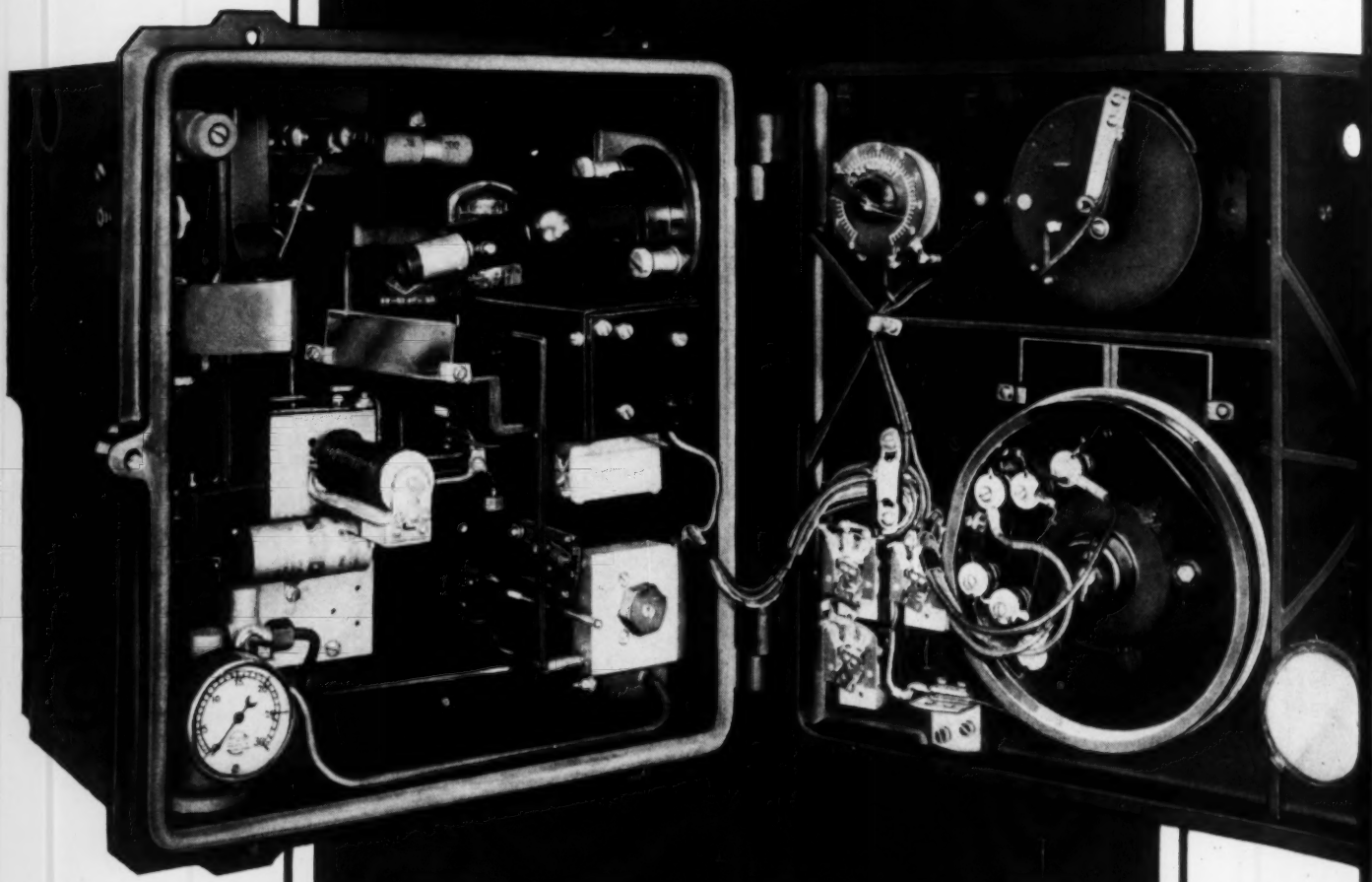

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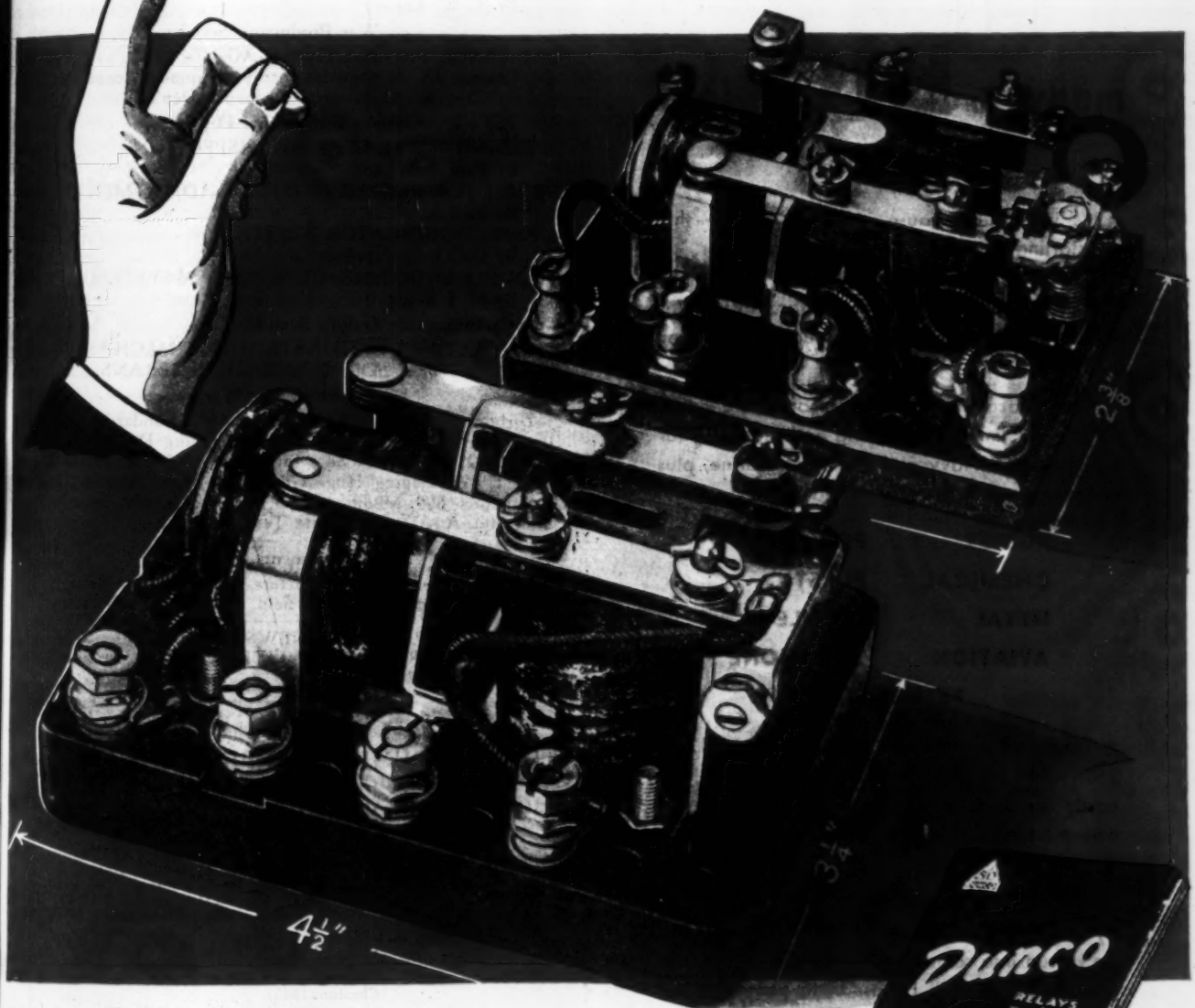

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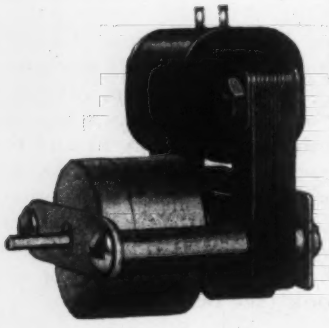

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Instruments

Vol. 16 NOVEMBER 1943 No. 11

COVER: Section of research laboratory of Lycoming Division of Aviation Corporation. Studies of torsional vibrations in experimental aircraft power plants are carried out here and play an important part in research and development. The operator is tuning a General Radio Wave Analyzer, suspended from a low-natural-frequency supporting structure in order to isolate it from shock and vibration. With the analyzer, the relative amplitudes of the individual components of the complex vibration spectrum are determined. *(Courtesy General Radio Co.)*

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Instruments THE MAGAZINE OF Measurement and Control

M. F. BEHAR, Editor

More Automatization Needed in Inspection and Gaging

WE Americans have prided ourselves, during the past half-century, on turning out more goods—and better goods—in fewer man-hours than could any other people on earth. We prided ourselves also on the high wages and high living standards of the workers in our modern manufacturing industries. Since January, 1914, we dimly understood that each of these two phenomena was both a cause and an effect, for it was then that Henry Ford made history by announcing a $5.00 wage minimum for an eight-hour day ($2.40 for a nine-hour day had been the average throughout his industries up to that moment). Of course, our automobile industry was our special pride—and rightly so—but the miracles of mass production efficiency made nearly all of our manufacturing industries stand high above those of other countries. Our dim understanding of the "high-wages-make-low-prices" *economic* formula gave way to a clearer understanding of the technological principles of *automatization* which are absolutely essential.

Now I have a confession to make. For a number of years I assumed that among all Americans, none understood this foundation of Productiveness better than did the instrument men in industry—whether mechanics or engineers or executives: all those men whose duties included the selection or design or application of measuring instruments, meters, gages, automatic controllers, inspection devices and other instrumentation products. To a certain extent I was right: real all-around instrument men have been and are the ablest introducers of American efficiency methods—the ablest substitutors of automatic devices for the human senses and human "guesstimation." But it begins to seem that competent instrument men haven't been exerting enough influence in America's war production.

Of course I am not referring to process industries which are admirably (if not yet completely) automatized. I am referring to most of the manufacturers of war-products components: specifically to the "Inspection" or "Testing" or "Quality Control" departments in such plants.

The pity of it, the irony of it—yes, the tragedy of it—is that the world-wide fame of American productiveness had been gloriously won by those very industries: the makers of automobiles, refrigerators, typewriters, razor blades, vacuum cleaners, radio receivers, washing machines and innumerable other products of American ingenuity.

Oh, yes, to be sure, America is out-producing her enemies. To be sure, most of these companies have reason to take pride in the high speed at which they converted to war goods, in the high quality of their products and in their high rate of total output. But most of them waste manpower and womanpower on repetitive human drudgery—on *useless* drudgery. The exact totals cannot be computed; perhaps they never will be known. But:—

1. If we pick at random any one of the thousands of different war-products components which is comparable to a peace-time component (say, a 1" O.D. and ¾" I.D. × 2" long hollow cylinder of the same material, possessing the same physicals and made to the same tolerances as the peace-time part) we shall generally find that the cost in man-hours per thousand units is far greater than that of the peace-time component; we shall find that the machining hours are fewer and that an enormously greater labor-content is attributable to gaging, testing and inspecting.

2. If we pick at random any single plant making a diversity of components (not so different from its peace-time line that a comparison would be impossible) we shall generally find that this plant's employees now include smaller percentages of salesmen and of machine operators, but higher percentages of paper workers and of employees in the inspection, testing and quality-control departments.

Why is this? I don't know. It would seem that there are several reasons, mostly psychological. Some people tell me that labor opposes modern methods (but most war-work speed-up ideas were contributed by labor, all the way from Walter Reuther's large-scale ideas to the thousands dropped in suggestion boxes). Some people tell me that management—even engineering management—has deteriorated into a group of sore-heads who spend their energies in fighting against, instead of coöperating with, ownership, labor and government (but as one whose professional and social contacts are in the managerial class, I see little truth in this accusation). Others whisper to me that an alarming percentage of our industrialists are "NAMzies" and "hatelers" just like "the big French industrialists who armed Hitler while preventing real Frenchmen from arming France" (but *these* whispers are hate-mongerings: I only know of one industrialist who prefers Hitlerism to democracy—and the FBI has his number). Others intimate that it's all the fault of "those damn bureaucrats in Washington" (but all war *production* is under the WPB and today the WPB is almost entirely made up of able, patriotic industrial executives and engineers). Others claim that good news from the battle fronts weaken the devotion on the production front (but inasmuch as all of us in industry have relatives and friends overseas I find this difficult to believe).

Perhaps the explanation is that we all *thought* we were so good at mass production that we didn't have to do better—and when a nation stops advancing in *any* field of activity, it starts slipping! We've *got* to do better!

You and I can't do much about paper-work (not all of which is filling out forms for bureaucrats) but we can do something to reduce the sum total of work which can be done better by automatic and semi-automatic devices for measuring, gaging, testing and grading.

For ten years *Instruments* has crusaded for automatizing our beloved Nation's industries not only in the fabricating and processing departments but in the inspection departments. As your editor I have always given preference to articles on these subjects. Since the National Emergency was declared four years ago I have never rejected an article containing ideas for speeding war work. All subscribers who have introduced such time-saving and labor-saving methods (or who know of such installations) should describe them, with diagrams and photographs if necessary. The war is not won! You can help shorten it; you can help save American lives, by sending in such descriptions. Share the know-how!

—MFB

Joint Meeting of the
Society for Experimental Stress Analysis
with the Applied Mechanics Division of the
American Society of Mechanical Engineers
will be held at
The Hotel Pennsylvania, New York City,
December 2, 3, 4, 1943
Inquiries should be addressed to Society for Experimental Stress Analysis, P. O. Box 168, Cambridge 39, Massachusetts.

DYNAMICS
A "Refresher" for Instrument Men

By S. R. WILLIAMS
Professor of Physics, Amherst College, Amherst, Mass.

The subject of dynamics deals with all sorts of motion and the forces and torques producing translational and rotational motion. It deals not only with motion as did kinematics, but enquires into the causes of motion.

Newton's Laws of Motion

Newton gave us three laws of motion which apply both to motion of translation and motion of rotation.

Translation. *Law 1. A body continues in a state of rest or of uniform motion in a straight line unless acted upon by some outside force.* We are familiar with the first part of this law, for we see bodies at rest all around us, and they don't move unless some force acts upon them.

Demonstration of First Part of Newton's First Law of Motion of Translation

(a) Suspend from a rugged support as in Fig. 1 a mass of 1 kilogram, *M*, by means of No. 8 thread. Tie to the under side of the kilogram mass a piece of ordinary wrapping twine. In any case the lower string should be stronger

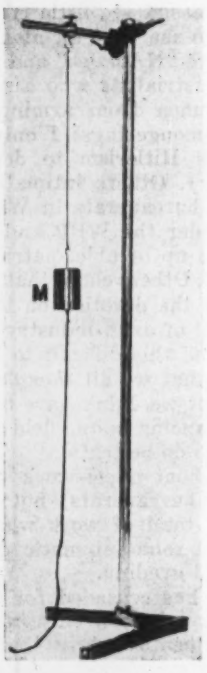

Fig. 1. A kilogram mass, *M*, is supported by a thread. To the underside of the mass is tied a piece of wrapping twine. A quick jerk on the lower and heavier cord causes it to break instead of the small thread.

than the supporting thread. On pulling the lower cord steadily, the upper thread will break, but if a quick jerk is given the lower and stronger cord, it will break in place of the weaker and upper thread. The kilogram mass refuses to be accelerated at the rate the jerk called for. This is a manifestation of the fact that matter once at rest seeks to stay put; it seeks to maintain its status quo.

(b) Place a visiting card on an outstretched finger with a coin (50-cent piece) on top of the card and directly above the outstretched finger as in Fig. 2. By snapping the card away quickly, the coin remains unmoved on the finger. In the same way a table cloth may be skillfully snapped from under the dinner dishes.

(c) A more formal device is shown in Fig. 3 in which a steel ball is laid on a visiting card which in turn lies on the top of a small post with a slight depression in the top. When the spring *S* is pulled back and released, the card is snapped from under the ball and the latter remains on the post. In the case of the coin, the dinner dishes, and the steel ball, they all possess inertia, the measure of their respective masses, and refuse to be accelerated or better they maintain their position of rest.

We do not see bodies, once started, keep on going forever in a straight line. Outside forces such as friction and gravity cause them either to stop or go in a curved path.

Demonstration of the Second Part of Newton's First Law of Motion of Translation

The nearest we can come to this type of motion is to roll a smooth steel ball on a piece of smooth plate glass. See Fig. 4. A large mirror, *G*, is carefully leveled and across it we can roll different sized steel balls, ¼", ½", and ¾" in diameter. This confines our motion to a horizontal plane and neutralizes the force of gravity. We see the balls roll in straight lines. If now we place under the mirror and as close as possible to the mirror a fairly powerful solenoid *S* with an ellipsoidal core *C*, of soft Swedish iron, then on exciting the solenoid with an electric current there will be produced a strong magnetic pole in the upper end of the iron core. If one of the steel balls is rolled to one side of

Fig. 2. The centers of a silver coin and of a visiting card are balanced over the end of a finger. When the card is snapped edgewise it slips away, leaving the coin still balanced on the finger.

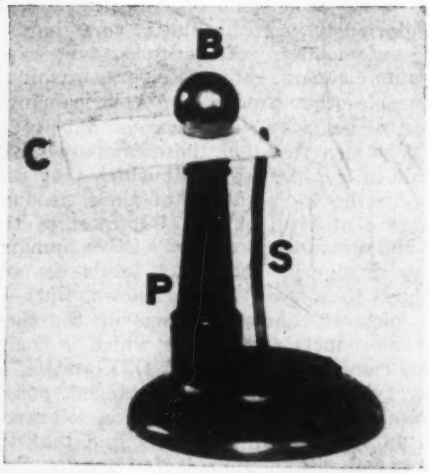

Fig. 3. A visiting card, *C*, is laid on the top of a small wooden post *P*. On top of the card and directly over the top of the post is placed a ¾" steel ball *B*. When the spring *S* is pulled back and released it will return and deftly snap the card from under the ball which will remain on the post.

the point directly above this magnetic pole, the ball will be attracted by the magnetic pole, and will swing into a curved path. An outside force has acted at right angles to the straight path of the steel ball and so it goes into a curved path. Again, if the magnetic pole had been placed either directly in front of or behind the steel ball, it would have been accelerated or decelerated. In any case, the outside force changes the velocity either in magnitude or direction. All of these cases show a change in the velocity of a mass and therefore a force is required.

The solenoid S used in this demonstration is about 20" long, about 2" inner free diameter, and 2080 turns of No. 12 DCC copper wire. The core (C, Fig. 4) consists of an ellipsoid of soft Rema iron. It is a bit more spectacular to use a concealed foot switch, M, when exciting the solenoid, so that the observers will not see when the deflecting force is applied.

Law 2. The rate of change of linear momentum is directly proportional to the force applied and takes place in the direction in which the force is applied. A body at rest has a velocity, $V_0=0$. If it begins to move, its velocity changes from $V_0=0$ to $V_t = t$. Therefore, the momentum changes and its rate of change will be

$$\frac{M(V_t - V_0)}{t} = Ma = F$$

$F = ma$ is a shorthand expression of Newton's second law of motion of translation.

Another of Dr. Williams' delightful series of "demonstrations on paper."

(Thin aluminum disk wheels are desirable.) The wheels used here are about 3" in diameter, while the body is just a block of wood, 4½" ×14" × ⅞". At the ends of the blocks are screw hooks and fasteners for holding either rubber bands or spiral springs.

When a light rubber band connects the two carts and they are separated as far as possible on the mirror lengthwise, the same force F (elastic force of stretch of the band) acts on both carts. When both carts are released simultaneously, their accelerations will be the same since their masses are the same.

$$F = m_1a_1 = m_2a_2$$

When $m_1 = m_2$, then $a_1 = a_2$.

Put a kilogram mass on one cart and again separate the carts with the rubber band stretched between them. Again F is the same for both carts and their loads, but m_1 does not equal m_2 and, therefore, a_1 does not equal a_2. For any given mass the acceleration will be directly proportional to the force applied. On the other hand, this outfit may be used for determining the mass of a body for

$$m_1/m_2 = a_1/a_2 \text{ or } m_2 = (m_1a_1)/a_2$$

where m_1 and a_1 represent the mass and the accelerations of a standard mass.

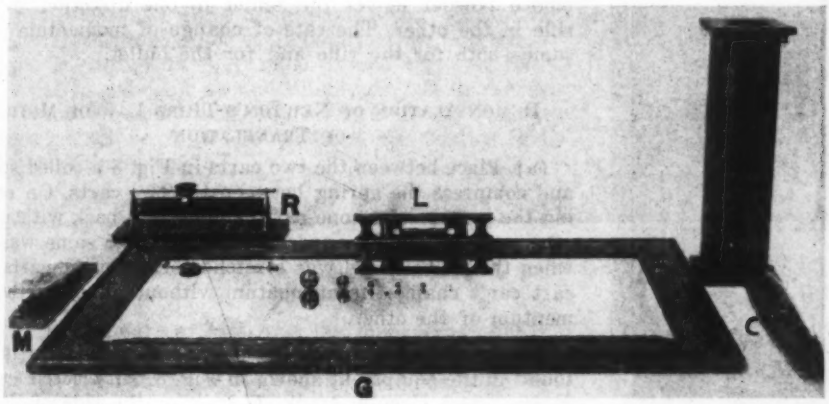

Fig. 4. The solenoid, *S*, with its ellipsoidal core, *C*, is placed in an upright position directly under the center of the mirror. The rheostat, *R*, and foot switch, *M*, go under the table and control the current in the solenoid. The level, *L*, is for leveling the mirror.

A wooden ball rolled on a bowling green is retarded by the grass and finally comes to rest. Its rate of change in momentum in slowing down is due to the force of friction received from the grass.

Demonstration of Newton's Second Law of Motion of Translation

(a) Two light, four-wheeled carts, C_1 and C_2, are arranged to roll over the surface of the mirror G shown in Fig. 5. The wheels are made with as small moments of inertia as possible and with little friction in the bearings.

(b) The Classical Monkey Problem. Over a frictionless and inertialess pulley is hung a long rope with a monkey on each end. If one monkey starts to climb his rope, what happens to the other monkey? The answer to this problem is found in Newton's second law of motion of translation and is demonstrated by the device shown in Fig. 6. In lieu of the two monkeys, two small electric motors, M_1 and M_2, of equal masses, are attached to the ends of a light cord. Each motor has a wind-up drum driven by a worm gear on the shaft of the motor. The wires leading to the motors are made as light and flexible as possible and hitched up

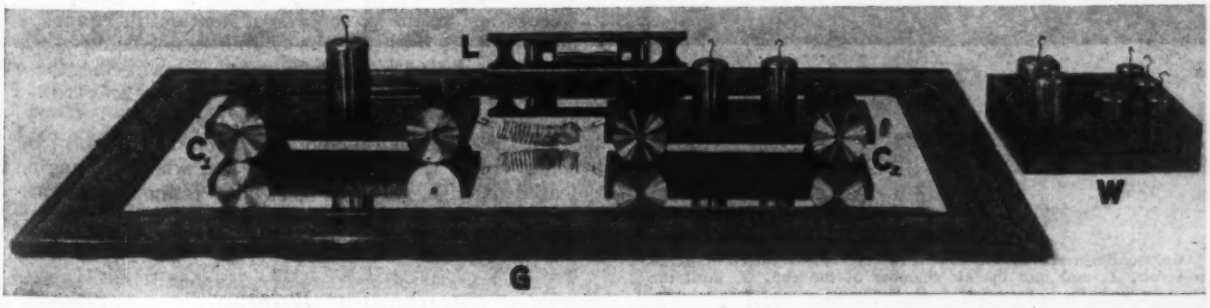

Fig. 5. The stretch of a spring or of a rubber band give the same accelerating force to each cart. The accelerations of the carts will be inversely as their masses.

so they won't drag or pull the motors. In order to have complete control of the motors, lead wires run out from both the field and the armature to reversing switches so that the motors can be accelerated both up and down in their movements. If one motor starts upward, this means an acceleration, and since an acceleration means a force or tension along the cord, the same force will be pulling on the other monkey, and he in turn will be accelerated upwards, and so *he* goes up as well as the other, because

$$F = m_1 a_1 = m_2 a_2 \text{ and when } m_1 = m_2 \text{ then } a_1 = a_2$$

Various combinations of motions for the monkeys can be worked out.

Fig. 6. If while the two motors are at rest an electric current is sent through one of them, it will be accelerated either up or down. Since the same force acts between the motors, the second motor will also be accelerated up or down. *S* is the control switch and *T* a spool of heavy thread. *A* is the head to an old Atwood machine.

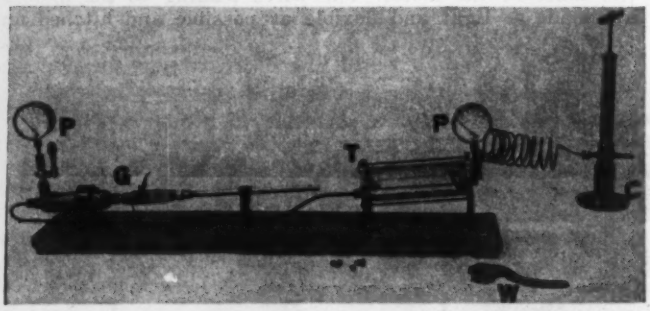

Fig. 7. By means of the compressor, *C*, air is forced into the reservoir, *T*, and into the air chamber of the gun, *G*, until the pressure in both pressure gages, *P*, *P*, shows several atmospheres. A steel ball is then fired by the compressed air in *G* which hits a flap over a circular opening in *T*. The sudden stopping of the steel ball sets up such a force that the steel ball enters *T* under the same pressure as is in *G*.

(c) When an automobile traveling at a high rate of speed strikes a big tree, the force of impact becomes enormous, because the momentum, mv, of the automobile is changed so suddenly.

This sudden change in momentum can be demonstrated by means of the apparatus shown in Fig. 7. *G* is a compressed-air gun, which uses a ½" steel ball for a projectile. By means of the compressor, *C*, the pressure of the air in the gun can be pumped up to any desired pressure shown on the pressure gage, *P*. Connected to the air chamber of the gun is a glass tube, *T*, with brass ends and sealed so as to stand the air pressure shown on the two gages which register the same pressure. The brass end of *T* nearest the muzzle of the gun has an opening in it large enough to admit one of the steel balls. It is sealed off, however, by a thick leather pendant flap inside the brass end. When the gun is fired with the muzzle velocity of v, the momentum of the steel ball on striking the leather flap is mv. If the flap does not open, the change in momentum is very rapid, and therefore a large force is put on the flap because of the change in momentum of the steel ball. The enormous change in momentum of the ball causes it to push the flap open and force its way into the tube, *T*, against the same pressure of air which fired it.

Law 3. Action and reaction are equal. To every force action there is an equal but opposite reaction. One body cannot begin to move, i.e., change its linear momentum, without affecting some other body. A bullet as it moves out of the barrel of a rifle reacts on the rifle itself, and the rifle kicks back. The expansive force of the gas from the exploded powder drives the bullet in one direction and the rifle in the other. The rate of change of momentum is the same—both for the rifle and for the bullet.

Demonstration of Newton's Third Law of Motion of Translation

(a) Place between the two carts in Fig. 5 a coiled spring, and compress the spring between the two carts. On releasing the compression, one cart cannot start back without the other starting in the opposite direction. The same was true when the rubber band was stretched between the carts. One cart can't change its momentum without affecting the momentum of the other.

(b) Another instructive demonstration of this law is to be found in the equipment shown in Fig. 8. An electric engine, *E*, runs on a circular track, *T*, built on the side of the rim of a bicycle wheel whose axis is vertical. The wheel with its track is leveled and every part balanced as carefully as possible. By means of sliding contacts the electric current (a.c.) is led to and from the rails of the track. A small variable transformer, *V*, gives opportunity for suddenly accelerating or decelerating the engine even when it is running.

With all parts of the apparatus at rest, the current is switched on and the wheels of the engine begin to turn. Due to friction between the wheels and track a push is given forward to the engine and a backward thrust on the track. Action and reaction are equal; therefore, the engine goes forward in one direction and the track in the opposite. Next hold the track fixed and get the engine up to a uniform speed. On releasing the track it remains at rest. According to the first law of motion it cannot start a motion of its own, for the engine is not being accelerated: it is running with uniform speed. By varying the current and so varying the speed of the engine, the track can be set in motion either forward or backward.

On the other hand, hold the engine at rest until the track comes up to a constant speed; and when the engine is released it also stays at rest and cannot accelerate itself unless more or less current is sent to the engine to change its velocity, which in turn accelerates the track.

Rotation

Newton's laws for rotary motion are expressed in a fashion analogous to those for motion of translation.

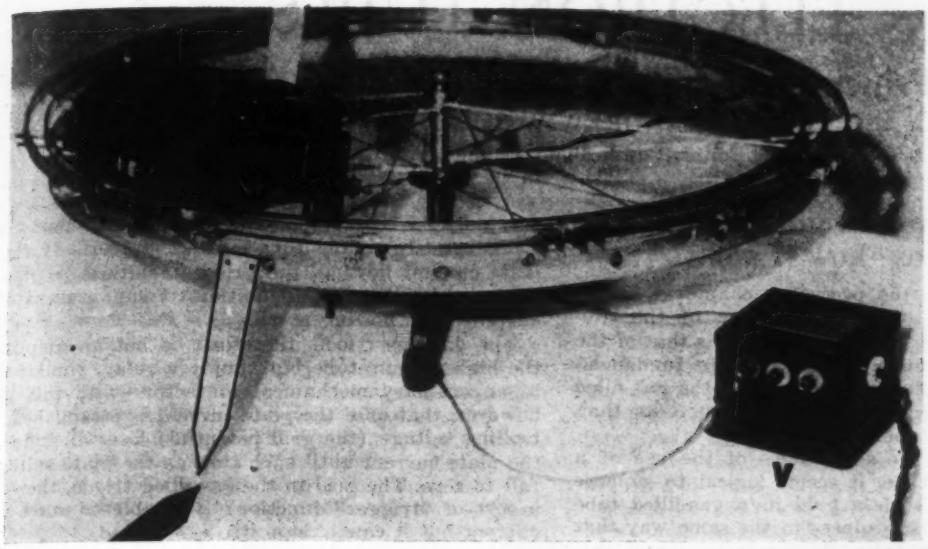

Fig. 8. When an electric current starts the wheels of the engine to rotating, the engine will go in one direction and the track in the other. Action and reaction are equal.

Law 1. A body continues in its state of rest or of uniform gular rotation unless acted upon by some outside torque. ere again the first part of this law is quite familiar to us.

Demonstration of Rotational Inertia

(a) Fig. 9 shows a beautiful production of mechanical aftsmanship. It is a light aluminum wheel (made by ncretet) carefully mounted and balanced on a ground el shaft. In turn this shaft rolls on the edges of four ner accurately cut and ground aluminum wheels whose les have cone-bearing points. The outfit is the head of an l Atwood's machine. The friction is rolling friction and erefore exceedingly small.

If the entire outfit is rotated about an axis coinciding th the axis of the large wheel, it will be observed that e large wheel does not turn. Because of its rotational iness (inertia) it refuses to turn with the rest of the paratus.

(b) The second part of this first law finds examplifica- n in the rotation of the earth. Once started it has kept ever since. We may later decide that the tides influence s rotation; but, if so, we haven't been able to detect any nge in the length of the second since we had the science astronomy.

(c) A nicely balanced bicycle wheel when outfitted with e best of ball bearings will keep on rotating for a long ne once it is set into rotation. The more we reduce fric- n the longer the wheel continues to rotate. Sperry's del gyroscopes are good illustrations of a body continu- to rotate for a long while. An accurately ground steel l weighing 30 to 40 pounds will spin for an astonishingly g time when supported, in a cup ground to fit the ball, compressed air forced into the bottom of the cup which sults in a thin cushion of air between the ball and the p, that is to say, an almost frictionless bearing.

Law 2. The rate of change of angular momentum is pro- rtional to the torque applied and takes place in the direc- n in which the torque is applied. A torque is defined as t which produces or tends to produce angular accelera- n. It is also defined as the product Fr in which we have force F acting at an arm's length, r. Thus Q, the torque, Fr. A body at rest has an angular velocity of $\omega_0 = 0$. If begins to rotate, its velocity changes from $\omega_0 = 0$ to $= t$. Therefore the angular momentum changes and its e of change will be

$$I(\omega_t - \omega_0)/t = I\alpha = Q = Fr$$

$Q = I\alpha$ is the shorthand expression for the second law motion of rotation. A crank hanger, Fig. 10, gives a good ustration of a variable torque. Let the force of the 2-

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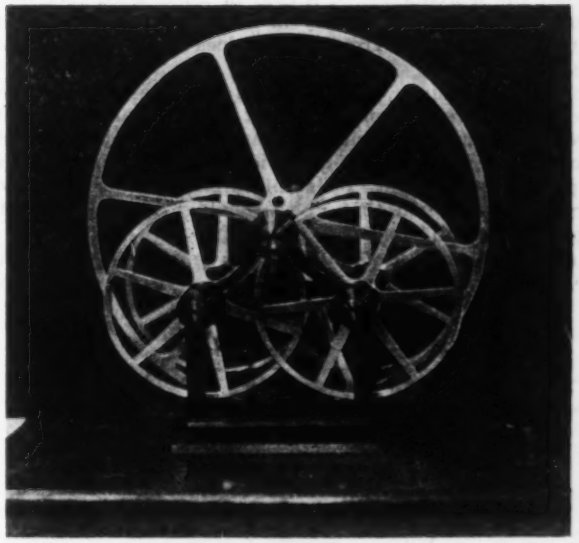

Fig. 9. A fine example of careful workmanship—a roller bearing. This is the head of an old Atwood machine shown in Fig. 6.

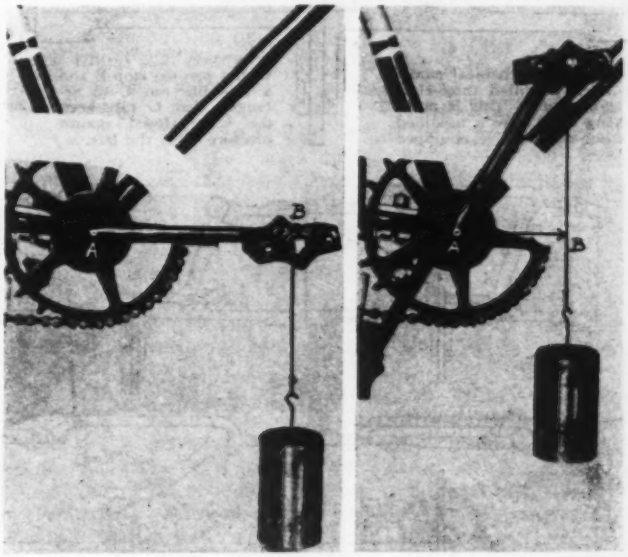

Fig. 10. A 2-kilogram mass hangs on the pedal of a bicycle. Its effectiveness in producing rotation is greater in the position to the right than in the position to the left, because *A-B* is greater in the first case than in the second and the torque is proportional to *A-B*.

ELECTRON TUBES

Their Principles and Their Instrumentation Applications

By ANDREW W. KRAMER

Managing Editor, Power Plant Engineering, Chicago, Ill.

CHAPTER VII

THE THYRATRON: HOW IT WORKS

It will be evident from the preceding chapter that the action or, more correctly, the circuit action of the two-element gas-filled tube is essentially the same as that of the two-element high-vacuum tube. Both types are fundamentally rectifiers, the only difference being that the gas-filled tube is capable of carrying much greater currents than the high-vacuum rectifier tube.

Knowing something of the advantages of the use of a grid in the high-vacuum tube, it seems logical to suppose that the introduction of such a grid in a gas-filled tube would extend its range of usefulness in the same way that it does in the high-vacuum tube. To a certain extent this is true: the introduction of a grid in a gas-filled tube does extend its usefulness, greatly in fact, but it does so in an entirely different way from what it does in the high-vacuum tube.

In a high-vacuum tube the grid exercises almost complete control over the plate current: it can start it, stop it, increase or decrease it, indeed it can cause the plate current to follow any variations of the grid potential no matter how complex or how rapid. It is this almost complete control function of the grid that gives the high-vacuum tube its property of amplifying.

As soon as a small quantity of gas is introduced into the tube, however, this "modulating" power of the grid upon the plate current ceases and instead it assumes only the comparatively simple function of "starter." If there is no plate current flowing, the grid can initiate its flow at any time, or, by the same definition, it can prevent the plate current from flowing at all.

The gaseous triode, therefore, is not an amplifier as is the high-vacuum tube but simply a relay, similar in action to an ordinary mechanical contactor—with this difference, however, that once the plate current is established, the controlling voltage (the grid potential) loses all influence over the plate current until such time as the plate voltage might fall to zero. The grid in the gas-filled triode, therefore, has a sort of "trigger" function: it is able to start the plate current but it cannot stop it.

A Mechanical Thyratron

The action can, perhaps, best be explained by the mechanical analogy depicted in the accompanying diagrams. These diagrams show the operation of a check valve in a pipe line —not an ordinary check valve but a modified check valve designed specially to simulate action of the gas-filled three-electrode tube: it is in fact a mechanical thyratron.

As will be noted in Figs. 42 and 43, it consists of an ordinary non-return type of valve, *A*, to which is attached a short movable stop, *B*, so arranged that when the valve *A* is closed, the stop rests horizontally on the projection *D*. In this closed position, the movable pin *C* is raised, the valve is locked in position so that even with pressure on the left

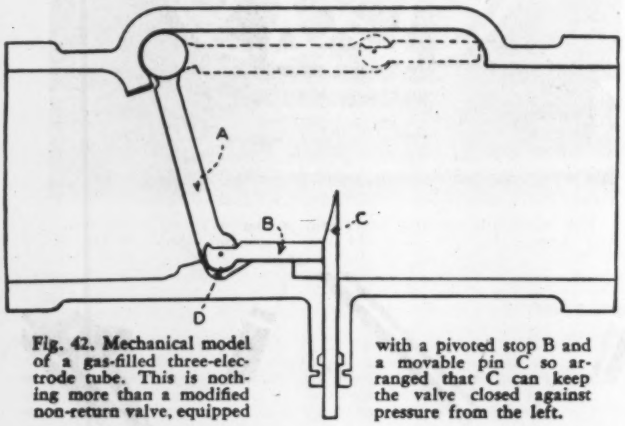

Fig. 42. Mechanical model of a gas-filled three-electrode tube. This is nothing more than a modified non-return valve, equipped with a pivoted stop B and a movable pin C so arranged that C can keep the valve closed against pressure from the left.

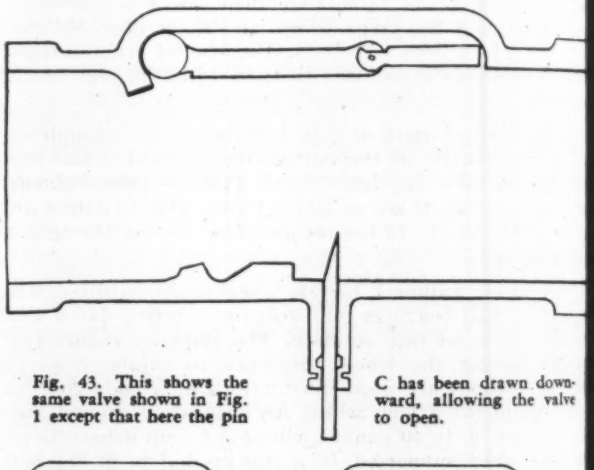

Fig. 43. This shows the same valve shown in Fig. 1 except that here the pin C has been drawn downward, allowing the valve to open.

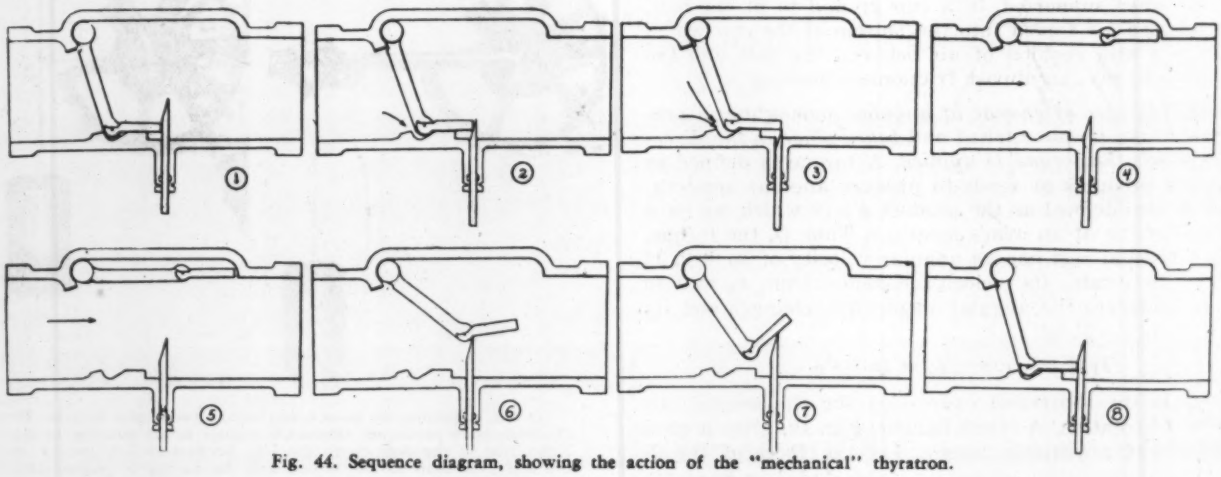

Fig. 44. Sequence diagram, showing the action of the "mechanical" thyratron.

ide of the valve, the valve remains closed. Under these onditions, it is readily seen that the valve can be opened nly by lowering the pin *C* to a point where it will no longer old the stop *B* in place.

The sequence of action is shown in Fig. 44. At 1 the valve s completely closed and even with full pressure on the left ide of the valve no flow occurs. At 2, the pin *C* has been ulled down a small amount. Since its upper part is beveled, t can be seen that this permits the valve to open slightly, nd there is some leakage past the valve. At 3, the pin has een moved downward to a point where it is almost ready o release the valve. At this point the valve has opened an ppreciable amount and there is still more leakage past the alve. At this point also, a slight further downward motion f pin *C* will suddenly release the valve entirely and the full pen position of the valve is attained instantly.

With the valve open and pressure on the line, the flow hrough the valve will continue as long as the pressure con- inues. Under this condition, pin *C* can be moved upward or ownward with no effect whatever upon the flow. In other ords, the pin has lost all control over the flow.

Should the pressure in the line reverse, or should it re- uce to zero for an instant, the check valve would tend to lose as in the case of any ordinary non-return valve. As- ume that pin *C* is up at such a time. It can readily be seen

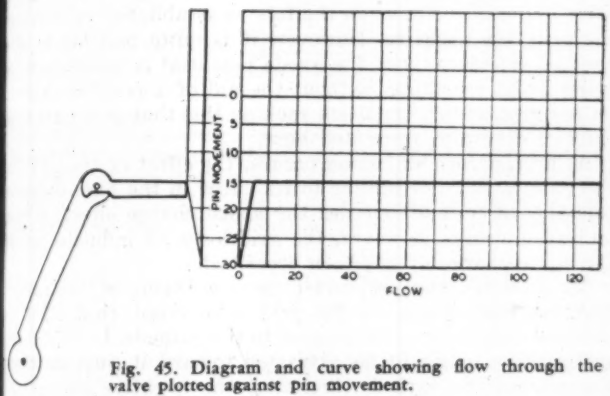

Fig. 45. Diagram and curve showing flow through the valve plotted against pin movement.

hat if no provision were made to avoid it, the pin might nterefere with the closure of the valve. The construction of his valve, however, is such that such interference does not ccur. The stop, *B*, is pivoted in such a manner that as it omes in contact with pin *C*, as shown at 6, it rotates on its earing and thus slides past the pin as shown in 6, 7 and 8. t 8, it will be noted, the valve is entirely closed and locked position by the stop and the pin. Thus, the pin regains ntrol; even if the pressure is reëstablished, the valve can- ot open until the pin is withdrawn again.

The simple action almost exactly simulates the action of e thyratron or gaseous triode. Pin *C* corresponds to the id and its position, up or down, corresponds to the value f the grid potential. The flow through the valve, of course, equivalent to the plate current.

In Fig. 45, for the sake of comparison, the flow through e valve is shown plotted against the pin movement. As is ite obvious, as soon as the pin is moved slightly by reason f the bevel, the valve starts to leak and a small flow is tablished. This leakage accounts for the steep slope at the ft side of the graph. Then, as the valve is released, the ll flow is established as shown by the horizontal part of e graph. (To make this graph "right side up," the valve nd pin have been reversed.)

Now, compare this graph with the grid-potential plate- rrent characteristic of the gas-filled triode shown in Fig. 6. As will be seen, it is identical with the graph of the lve which has just been analyzed. With a high negative otential on the grid (–30 volts in this example) there is no rrent through the tube. As this negative voltage is re- uced, a small plate current begins to flow (which corre- onds to the leakage through the valve during the early portion of the pin travel). At this point, the gas-filled tube resembles the high-vacuum tube. As the grid potential is still further reduced there comes a time (–15 volts arbitrarily assumed here) when the gas in the tube ionizes and the tube almost instantly becomes conducting. Maximum plate current flows. In other words, at this instant there is a sudden change in the tube's characteristics: its resistance which until this moment has been high, now suddenly drops to a low value.

This also, it will be obvious, is the case in the hydraulic analogy. Until the pin has moved to the point where it entirely releases the valve, the resistance to the flow is extremely high. Then, suddenly, as the valve is released, the resistance drops to an extremely low value.

In the case of the gas-filled tube also, the plate current rises practically to its full value, limited only by the emission of the cathode or the external resistance in the circuit. With the valve, the flow is limited by the capacity of the pump or head supplying the flow and, of course, by the resistance of the pipe line. Here the pump corresponds to the cathode.

From the foregoing description and explanation it must be evident that the gas-filled three-electrode tube is a very sensitive current or voltage relay. Also, it is fast in its action—only a few microseconds may be required for the

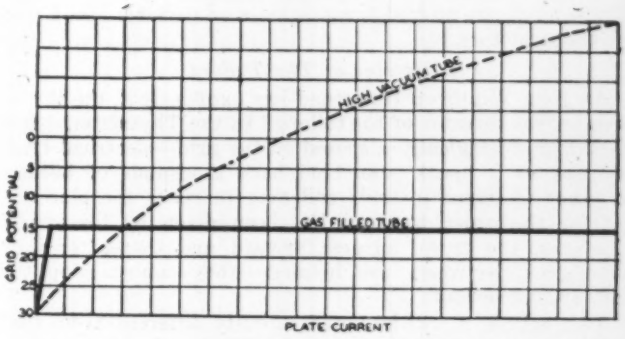

Fig. 46. Grid-potential plate-current characteristic of the gaseous triode and also a similar characteristic for the high-vacuum tube.

tube to operate, once the proper grid voltage has been attained to permit plate current to flow. Thus, if 15 volts negative on the grid will prevent current flow, a change of say only 0.1 to 14.9 volts negative may produce ionization and permit a current of many amperes to flow. Indeed, hundreds or even thousands of amperes may thus be turned on by a mere fraction of a volt applied to the grid. It is, in fact, much like releasing the latch to a gate.

The term Thyratron as used to denote a three-element gas-filled tube means just exactly that—a gate. Thyratron is one of what De Forest has called the Greco-Schenectady names applied to various kinds of tubes. The suffix "tron" signifies an object that is used as an instrument or tool. Thus kenotron freely translated means "a tool that has nothing in it," the Greek word preceding the "tron" meaning "empty space."

In the same way, thyratron is derived from the same Greek word meaning "door," or "gateway" from which "thyroid" is formed in designating the thyroid gland. Thyratron thus means a "tool or instrument that can be opened like a door."

And that, really, is all there is to it. If you understand this simple action, you understand the fundamental principle of the gaseous three-element tube known as the thyratron (or sometimes as the grid glow tube). True, the "physics" of its operation is more complex and in its application many of the circuits with which it is associated are quite involved, but such complexity cannot be attributed to the tube itself. The tube and its action remain the simple thing we have explained.

Gas-filled triodes, obviously, cannot be used as amplifiers as are triodes of the high-vacuum type. They can be used

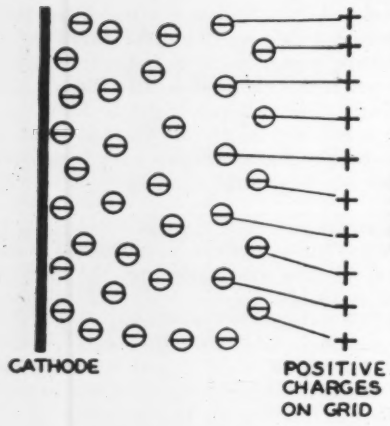

Fig. 47. Diagram showing the conditions which prevail in the high-vacuum tube or in the gaseous tube before ionization.

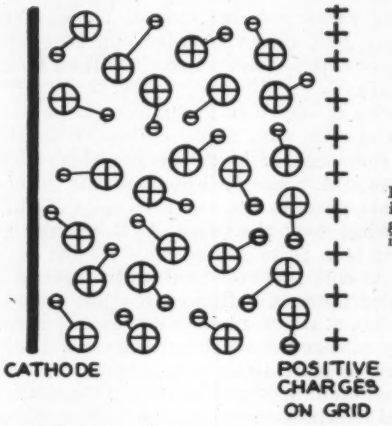

Fig 48. Diagram showing conditions in the gaseous tube when ionization is taking place.

as rectifiers, just as the two-element gas-filled tubes, but because of the grid and its action upon the plate current these tubes have a much more extended field of use than the ordinary rectifier. The gas-filled triode is a special type of rectifier—a rectifier of versatile and amazing possibilites, with properties which adapt it not only for use as a rectifier, but also as an inverter[1] or as a frequency changer. It makes possible electronic voltage regulators or such strange things as direct-current transformers or variable-speed synchronous motors.

Director of The Toilers

As John Winthrop Hammond has expressed it, the thyratron is "the director of the toilers." In the Thyratron, a few electrons strategically disposed on the grid—electrical traffic cops so to speak—can hold back thousands of billions of other electrons in their endeavor to reach the plate.

Once the order to move has been given by these grid electrons, the crowd surges forward and thereafter they (the grid electrons) are helpless—they cannot stop the forward movement.

This action, it will be noted, is quite different from that obtained in the high-vacuum tube. There, the grid always retains full control of the electron current—it can stop it as easily as it can start it. Let us investigate the reason for this difference.

In the high-vacuum tube the potential on the grid serves to aid or oppose the space charge effect. Space charge, it will be recalled, is the repelling effect upon electrons emitted from the cathode of all the electrons in the space surrounding the cathode.

Fig. 47 is a simple diagram which endeavors to explain this effect. It shows a cathode surface and the positive charges on a grid with the space between filled with electrons. Ordinarily, with no charge of any kind on the grid, these electrons tend to repel those electrons just emerging from the grid. With a positive charge on the grid as shown, however, each positive charge neutralizes the effect of one of the negative charges (electrons) and so the total negative effect is diminished by just that amount. This represents the high-vacuum condition.

Suppose, however, that instead of the vacuum the space inside the tube is filled with as many positive ions as there are electrons, as is the case in a gaseous tube in which ionization is taking place. With this condition, shown in Fig. 48, there is, of course, no space charge effect since the effect of each electron is neutralized by that of a positive ion, and since there is no space charge the grid potential can have no effect—the grid is inoperative.

This is not usually the way in which a gaseous triode is operated. Usually the grid is maintained rather highly negative and current through the tube is established by making the grid less negative. However, it is quite possible to arrange a circuit so that the anode potential is insufficient to bring about ionization without the aid of a positive charge on the grid. It is a condition such as this that is depicted in the two diagrams presented here.

At first, before ionization occurs, the effect of the grid in the gaseous tube is similar to its effect in the high-vacuum tube, i.e., it aids or opposes the space charge effect. When ionization occurs, however, the grid loses all influence upon the space charge as has been described.

To continue, suppose under the conditions of ionization described the charge on the grid is reversed, that is, it is charged negatively with respect to the cathode. In this case, the positive ions will be attracted toward it, just as they are toward the cathode, and thus the negative charge on the grid will be surrounded by an equal positive charge. Hence, the influence of the negatively charged grid wires extends only a very short distance from the surface of the wire, not sufficient to have any effect on the stream of electrons flowing through it from the cathode to the anode. Having thus permitted the anode current to start, the grid is powerless to stop it.[2]

CHAPTER VIII

THE CONTROL FUNCTION OF THE GRID IN THYRATRONS

The gaseous triode or thyratron, as has been shown, is fundamentally a relay; it cannot be used as an amplifier as can the high-vacuum triode.

Since the function of a relay in an electric circuit is a relatively simple one, one may wonder why the thyratron

(1) A device for converting direct current to alternating current.

(2) This statement, generally, is true although it is possible to build a fine-mesh grid which, made sufficiently negative, will stop the current flow.

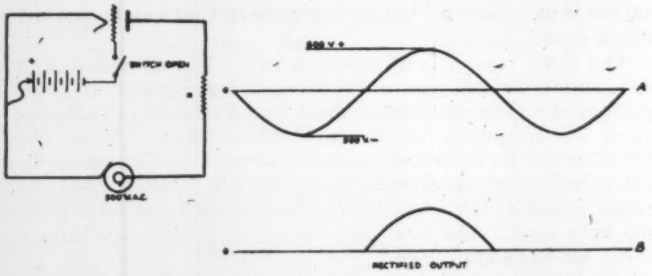

Fig. 49. With no potential on the grid, this 3-element tube functions merely as a rectifier.

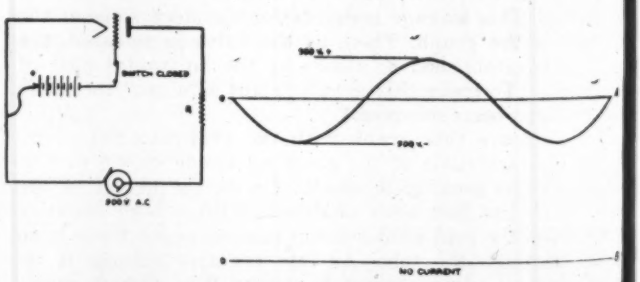

Fig. 50. When a high negative potential is applied to the grid, as in this case, no current flows through the tube.

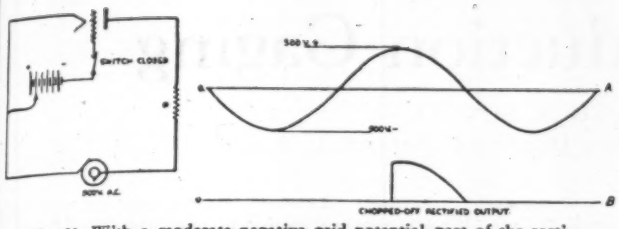

Fig. 51. With a moderate negative grid potential part of the rectified output is chopped off as shown.

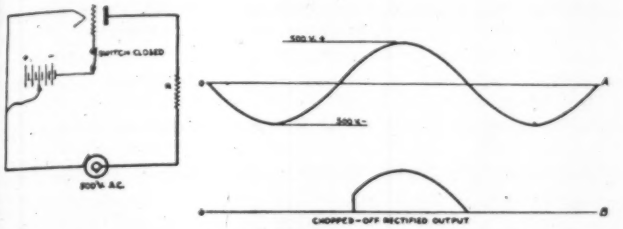

Fig. 52. Here a still lower negative grid potential is used.

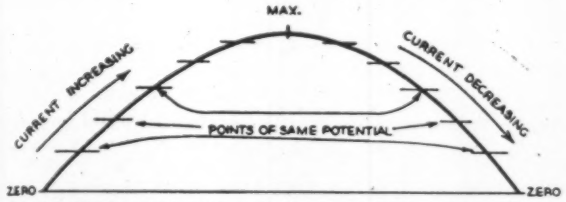

Fig. 53. During each half-wave, the same values of potential are passed through, twice.

has become such an important device in the field of electronics. In this and the chapters immediately following, an attempt will be made to answer this question and also to indicate the manner in which the thyratron is used in electric circuits.

In ascribing the function of relaying to the thyratron, it must be understood that this tube, like its two-element relative, is also a rectifier. This should be clear from our study of the tube thus far. In the diode the plate current flows whenever the plate is positive with respect to the cathode, but not when the polarity of the plate is reversed. In the three-element tube this also is true but in addition a variable control element in the form of a grid is introduced, which allows current to flow during the positive half of the cycle only when the grid permits it. In this type of tube, no current flows even when the plate is positive *unless* the grid permits it.

This controlling property of the grid is extremely useful in that it enables the start of the positive half-cycle of the alternating current to be delayed as long as desired.

The way in which this is accomplished will now be described in detail. Consider, for example, the circuit shown in Fig. 49. This, it will be noted, consists of a 500-volt alternator supplying current to a circuit containing a gaseous triode and a load resistance *R*. A grid battery is also provided so that a certain negative grid potential can be impressed on the grid. A switch is provided so that the grid potential can be cut in or out and a switching arrangement is provided so that the number of cells connected to the grid can be increased or decreased.

With the grid battery switch open as shown in Fig. 49, there is, of course, no potential whatever on the grid and the tube acts exactly as a two-element gaseous tube, that is, purely as a rectifier. Under these conditions, the negative half of the alternating current wave will, of course, be suppressed and current will flow only during the upper or positive half of the cycle, as shown at *B*.

Suppose, however, that the grid battery switch is closed as shown in Fig. 50, impressing the full grid battery negative potential on the grid. If this negative potential is high enough, as it will be assumed to be here, it will effectively block all current through the tube and no current will flow in the load circuit.

Now, let us assume that the grid potential is lowered somewhat by cutting out some of the cells of the battery as shown in Fig. 51. In this case no current will flow during the positive half cycle until the plate voltage has reached a certain definite value—a value, of course, which depends upon the grid potential. Here, this value will be assumed to be just under 500 volts, say 480. The result is quite obvious. The positive half-wave will be chopped off as shown in Fig. 51. The current rises instantly to a value corresponding to 480 volts and thereafter follows the sine wave variations of the remainder of the half-cycle in the usual way.

By still further reducing the negative grid potential by cutting out additional cells as shown in Fig. 52, the "firing point" of the tube—as it is called—is still further reduced and the tube will become conducting at a still lower plate potential. As a consequence current will begin to flow earlier during the positive half cycle as indicated at *B*, Fig. 52.

In the foregoing illustrations (Figs. 49-52) the start of the discharge through the tube is entirely dependent upon the steady value of negative potential impressed on the grid. Since in every half-cycle of an alternating current wave, the same values of potential are passed through twice (once when the current is increasing from zero to maximum and again when decreasing from maximum to zero, as shown in Fig. 53) it is evident that this simple method of control cannot cut off more than half of the positive cycle. That is, the wave can be chopped off like this ,
like this ,
or this ,
but not like this .

If it is desired to chop the wave off as in the last sketch, a time element will have to be introduced in the application or removal of the grid potential. If, for example, a high negative grid potential is maintained over a large portion of the positive half cycle and then suddenly removed as shown in Fig. 54, the plate current will flow only during a small portion of the latter half of the half cycle—shown by the shaded area.

Thus it is evident that by properly applying the grid potential, the thyratron can be set to chop off and use any portion of the rectified wave as shown in Fig. 55.

So far, only single half-cycles have been considered but it must be understood that this control of the current by the grid is repeated during successive half cycles of the alternating current wave as depicted at *B* and *C* in Fig. 56.

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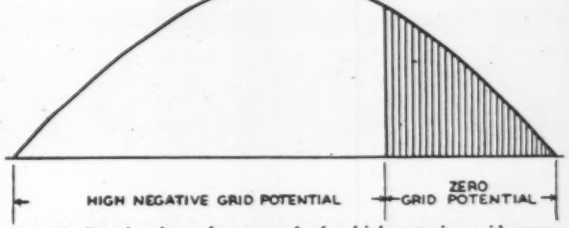


Fig. 54. Showing how the removal of a high negative grid potential can initiate the conducting period at any time desired.

Fig. 55. By properly applying the grid potential, the three-element gaseous tube can be used to "chop off" and use any portion of the rectified wave as shown here.

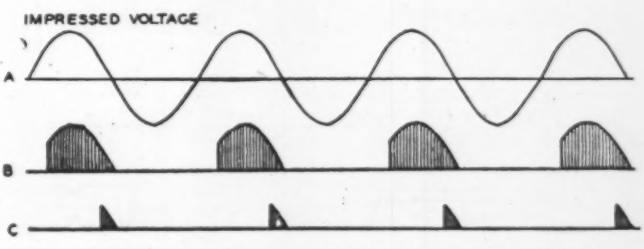


Fig. 56. Diagram showing control action upon successive half cycles.

Ordnance Production Gaging

By CAPTAIN RUSH A. BOWMAN
In charge of Pittsburgh Gage Laboratory, Ordnance Department, U. S. Army

CHAPTER IX
THE GAGE LABORATORY
(Concluded)

GROUP VIII

Taper Parallels, Small Hole Gages, Telescoping, Gages.

Taper parallels, Fig. 24, small hole gages, Fig. 25, and telescoping gages, Fig. 26, all have as their purpose the inspection of small holes by comparison methods. All require the setting or feeling of the hole with the instrument and then the checking of that size with a micrometer or some other measuring device. Small hole gages and telescoping gages can essentially provide a measurement of out-of-roundness, barrel shape, and bell-mouth. They cannot, however, provide an "effective" diameter of a hole—that is, the largest straight round plug which will go through the hole if any of the above conditions should exist. The taper parallels will provide such a check. Taper parallels are often used also in the inspection of a fixture type gage, where measurements are required from the effective center line of a hole. In such cases, the taper parallels are inserted, trued up on the sides, and left intact in the fixture throughout the inspection operation.

It is rather difficult to determine which of these three instruments should be included in the minimum-equipment laboratory. While all are used for the inspection of holes, and all are used by comparison and not as measuring instruments, the taper parallels on the one hand and the small hole and telescoping gages on the other hand do provide for the inspection of somewhat different properties of the hole. In view of their small cost, even a minimum laboratory will probably do well to have all three since all three, as a set, will provide for the inspection of every property of a hole—size, roundness, bell-mouth, barrel shape, diameters at particular points, effective diameters and exact center line.

No special care is required with respect to these instruments. They are, of course, subject to the normal requirements of cleanliness, freedom from burrs and scratches, wear, etc.

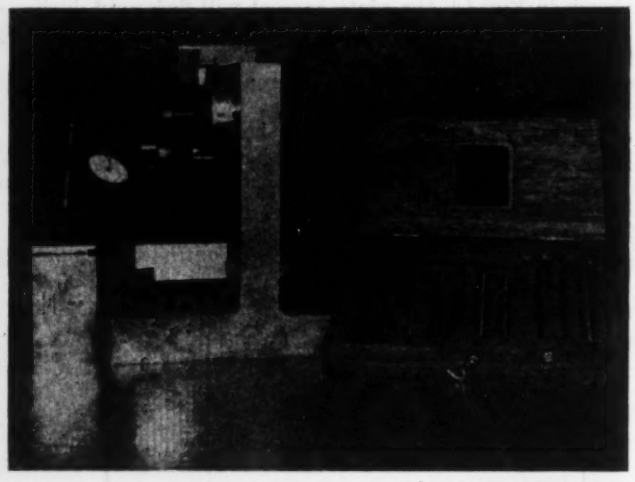


Fig. 24. A set of taper parallels being used to determine the position of the center line of a hole in a complicated fixture gage. Knowing the diameter by "miking" over the parallels, the position of the center line is determined by measuring height of top of hole as shown and subtracting radius.

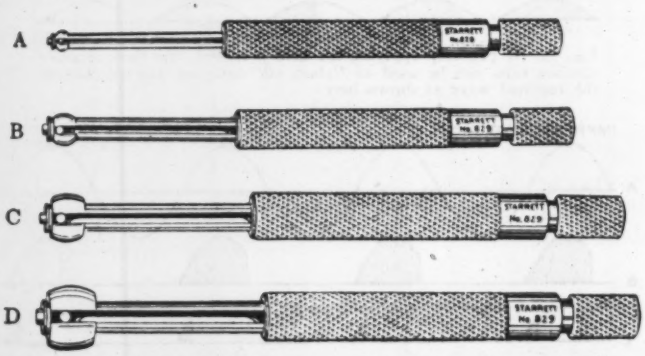


Fig. 25. Small hole gages, ⅛" to ½". (L. S. Starrett Co.)

GROUP IX

Parallels, Angle Plates, Parallel Blocks

Parallels, angle plates, and parallel blocks as shown in Figs. 27, 28 and 29, are general-purpose surface plate equipment. They will be required in almost all surface plate inspection set-ups. The particular sizes which will be required will be determined by the type of work and the size of work in the laboratory. The following should be sufficient for the ordinary laboratory with one or two people: three pair parallels 1½" × ¾", 1" × ½" and ¾" × ⅜"; three angle plates 5" × 8" × 10", 4½" × 5" × 8" and 2½" × 3" × 4"; two parallel blocks 4" × 4" × 6" and 4" × 8" × 6". Parallels and parallel blocks normally come flat ground. Angle plates are made flat ground and also scraped.

Special Care of Parallels, Angle Plates, and Parallel Blocks—Since this laboratory equipment is, of course, used for surface plate work, it is vulnerable to scratches and burrs. Extreme care should be taken that scratches and burrs when they occur are stoned off immediately so that they will not scratch other equipment with which they come in contact and so that inaccuracies in measurement do not occur.

This unique serial is based on the remarkably successful course of lectures by Captain Bowman (then Lieutenant) to us Reserve Officers, in which he combined the fruits of his civilian experience as Gage Supervisor and of his Ordnance training. —MFB

CHAPTERS PREVIOUSLY PUBLISHED. I. Interchangeability—Sept. '41 and May '42; II. Inside Dimension Gaging—July '42; III. Outside Dimension Gaging—Aug. '42; IV. Offset Dimension Gaging—Sept. '42; V. Position and Alignment Gaging—Oct. '42; VII. Profile Determinations—Dec. '42; VIII. Thread Gaging—Feb. '43; VI. Taper and Angle Determinations—Mar. '43; IX. Gage Laboratory Equipment—first instalment April '43, second instalment June '43.

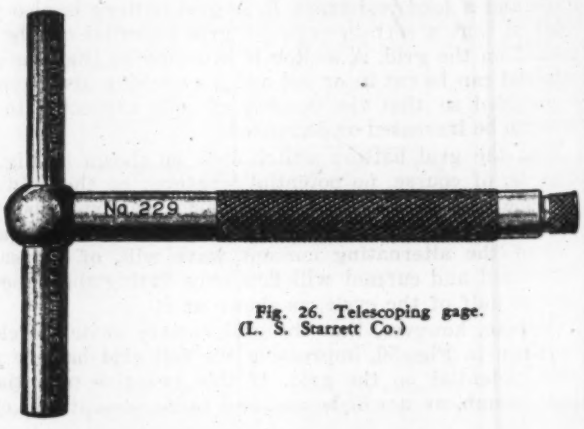


Fig. 26. Telescoping gage. (L. S. Starrett Co.)

Group X

olls

Rolls, see Fig. 29, are normally used in surface plate ork in the checking of tapers (see Chapter VII), in check- g for parallelism of anvils on snap gages, and in checking e diameter of rings (see Chapter III). The accuracy re- ired on rolls is normally 0.00001". As noted in the be- nning of this chapter, four sizes are recommended in pairs 0.100", 0.200", 0.250", and 0.500".

ires, Thread Checking

As noted in Chapter VIII, wires are used in the inspec- n of thread plug gages. Three wires comprise a set for e inspection of any one particular pitch. Of course, by lculation, a set of wires other than the "best size" for a rticular pitch may be used if the differential is calculated. ires may be bought in sets of sets; that is three wires ch for checking from 20 to 24 particular pitches between, r instance, four threads per inch and 80 threads per inch. a small laboratory, it might be felt wise to buy wires r, say, every fourth size pitch if economy is to be a factor. e actual size of the wires being known, calculations can made to take care of any pitch.

In the use of wires for inspection of threads, care should taken that the size of the wires is not changed by tem- rature from the body or the hands. Wires should be han- d either with a chamois or a pair of pliers with soft nvils, and always left in the measuring machine or com- rator until they have assumed the temperature of the g. If a surface plate is handy to the measuring machine comparator, it should be used to bring blocks, plug, and res to the same temperature. It should be made a habit at, when the wires are handled on their removal from a achine, they be placed on a surface plate. Of course, any her large surface of steel is satisfactory—not glass, which relatively a poor conductor of heat.

Special Care of Wires and Rolls—Since in almost every easurement involving wires or rolls, movement of the ire or roll is required after it has been put into position order to seat it properly in the thread, the rate of wear ill be relatively rapid. For this reason, a system should set up for the periodic reinspection or calibration of ires and rolls, and the results of these calibrations kept in the same container. Examination of the thread checking formula will disclose that since "*G*" is the size of the wire, and in the formula this is multiplied by 3, a deviation in the size of the wire will be multiplied 3 times in the final result. Thus, if each of the wires is, for instance, 0.00005" undersize, and the nominal size of the wire is used in calculation, the resultant measurement will be in error by 0.00015".

Fig. 27. Set of parallels in rack. (Taft-Peirce Mfg. Co.)

Group XI

Sine Block and Sine Bar.

These instruments, used exclusively in surface plate work, provide probably the most accurate method for determination of angles. The distance between the center lines of the rolls in a sine block or the buttons in a sine bar is accurate within ten millionths of the nominal size. With this distance as the hypotenuse, the right-angle triangle (which is determined by the plane of the surface plate, the plane passed through the center lines of the rolls or buttons and a line

Continued on page 690

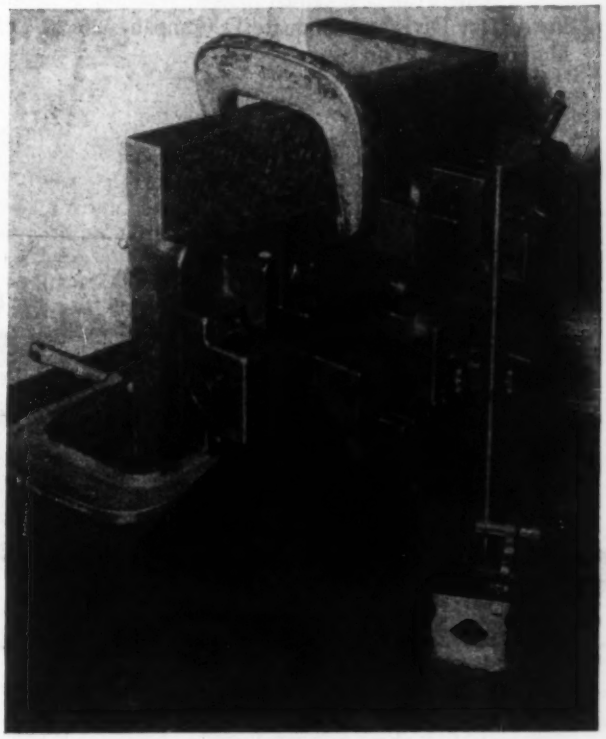


Fig. 28. Shown is the support of a fixture gage on an angle plate in order that the height of a flush pin surface may be taken by means of an indicator and height gage.

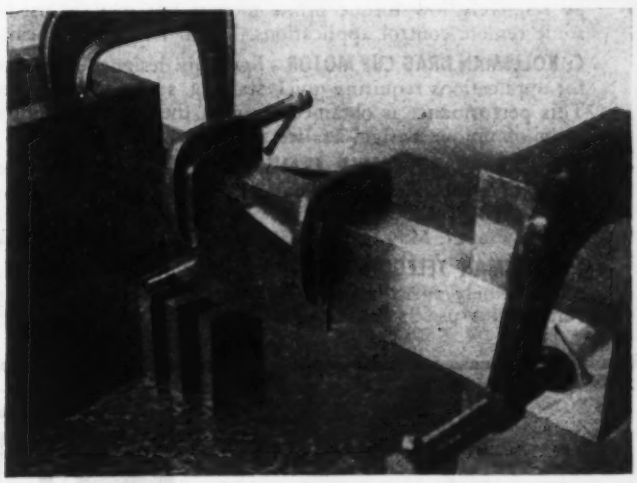
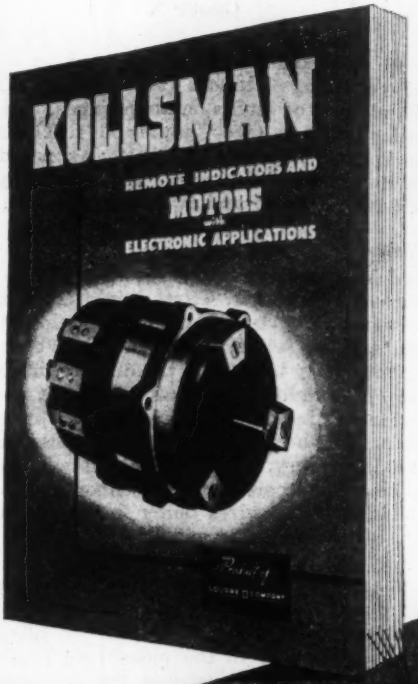


Fig. 29. In order to determine the position of the roll along the taper in this profile gage, the gage is clamped to a parallel which is supported by two parallel blocks.

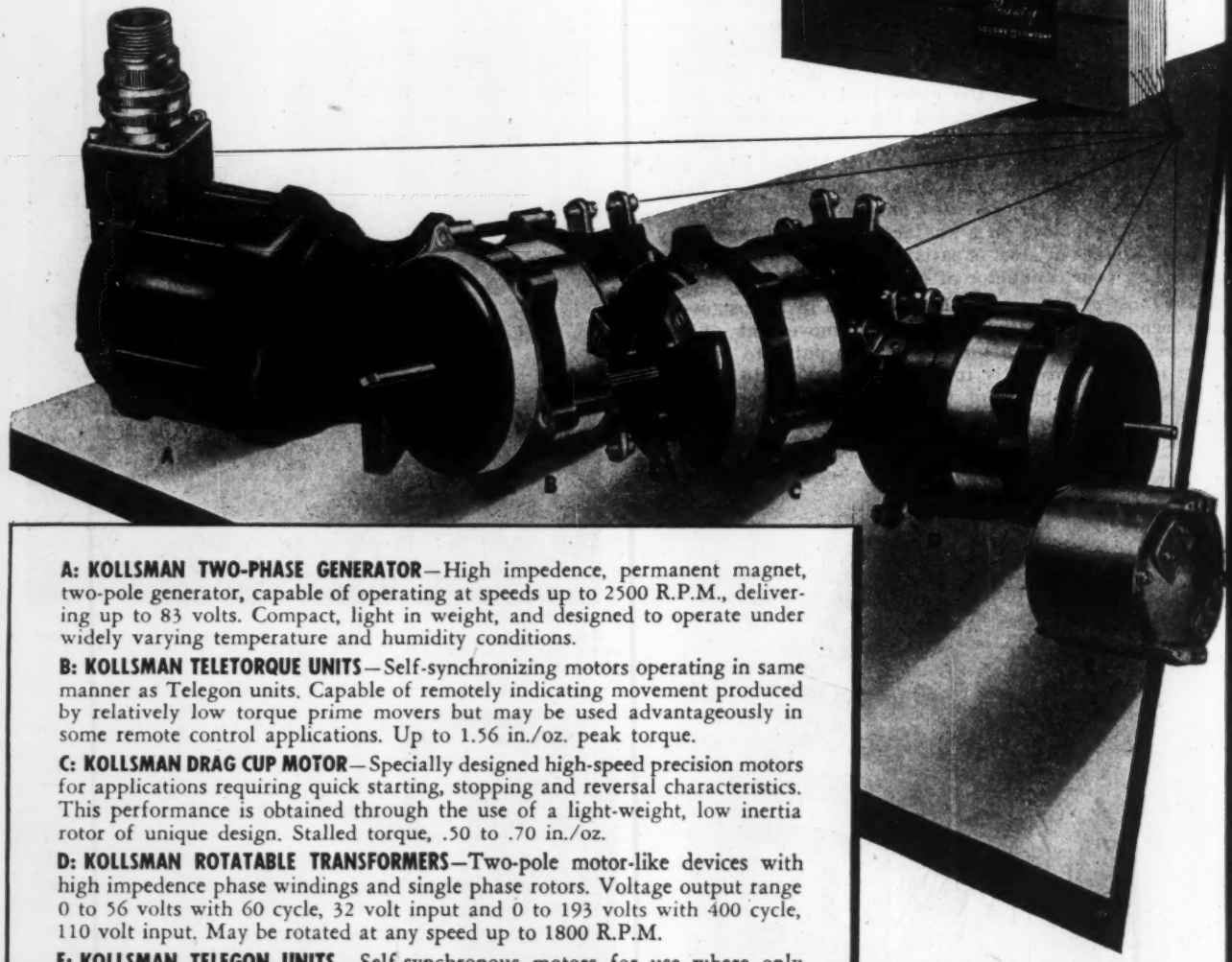
Design Engineers!

Kollsman Offers This New Line Of Miniature Motors For Special Applications



A new line of miniature motors with special remote indication and electronic control applications has been developed by Kollsman Instrument Division of Square D Company. Design engineers of electrical and electronic equipment manufacturers will find Kollsman engineers ready to assist them in applying and adapting these motors to their specialized requirements.

Complete information and performance data on the five units described here can be obtained from this catalog. Write to Kollsman Instrument Division of Square D Company, 80-20 45th Avenue, Elmhurst, New York.



A: KOLLSMAN TWO-PHASE GENERATOR—High impedence, permanent magnet, two-pole generator, capable of operating at speeds up to 2500 R.P.M., delivering up to 83 volts. Compact, light in weight, and designed to operate under widely varying temperature and humidity conditions.

B: KOLLSMAN TELETORQUE UNITS—Self-synchronizing motors operating in same manner as Telegon units. Capable of remotely indicating movement produced by relatively low torque prime movers but may be used advantageously in some remote control applications. Up to 1.56 in./oz. peak torque.

C: KOLLSMAN DRAG CUP MOTOR—Specially designed high-speed precision motors for applications requiring quick starting, stopping and reversal characteristics. This performance is obtained through the use of a light-weight, low inertia rotor of unique design. Stalled torque, .50 to .70 in./oz.

D: KOLLSMAN ROTATABLE TRANSFORMERS—Two-pole motor-like devices with high impedence phase windings and single phase rotors. Voltage output range 0 to 56 volts with 60 cycle, 32 volt input and 0 to 193 volts with 400 cycle, 110 volt input. May be rotated at any speed up to 1800 R.P.M.

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Vol. II, No. 11 M. F. Behar, Editor November 1943

Fixture for Speeding Visual Inspection and Size-grading of Glass Jewel Bearings

By PAUL S. WHITE
2214 Main Street, La Crosse, Wisconsin

GLASS vee-cavity jewels for instrument bearings are being used in lieu of sapphire jewels which are practically unobtainable by reason of the present high rate of instrument consumption. The jewel bearing selecting device illustrated in Figs. 1 and 2 was developed to speed up the grading of the different sizes of jewels; and also to facilitate the inspection of the jewel for glass bubbles and of the actual bearing surface for cracks and scratches, by use of the binocular microscope which is mounted directly over the sliding scale holding the jewel. By placing the jewels pivot end up in the holes on sliding scale *D* and passing it over microscope *G*, and defects may be immediately detected, and the defective jewel removed. If, however, the jewels are satisfactory, the scale is moved forward, stopping directly underneath the bracket *E*, which contains punches whose points are mounted over a series of holes drilled and carefully ground to correspond with the punches of diameters varying from 0.073″ to 0.079″.

As the foot pedal, connected to the bracket by rod *A*, is depressed, the punches drop into the vee cavities of the bearings and, if the proper jewel is over its respective hole, it is forced down, very lightly of course, through tube *F* into its properly labeled glass container. Then the bracket is raised automatically by springs into normal operating position.

Using a minimum of practice, an efficient operator may be trained for the inspection and grading, at the same time maintaining a quantity of production with no rejection of defective jewels and no risk of a jewel being forced into a jewel screw which may be drilled too large, or assembled in a screw with a hole too small, for the jewel's outside diameter.

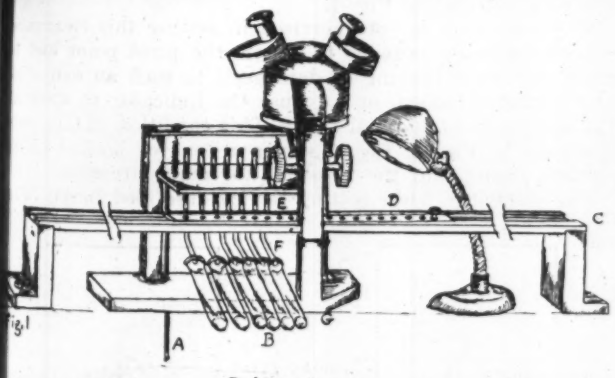

Fig. 1

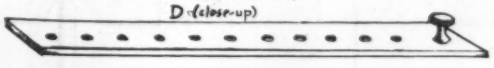

Fig. 2

A. Tie rod for connecting stamping bracket to foot pedal.
B. Glass containers for receiving six different sizes of jewels.
C. Sliding bracket into which scale D fits for presenting jewels to be inspected.
D. Sliding scale with holes used as recesses for jewels.
E. Bracket which moves up and down into which are inserted six different sizes of punches whose points are round at the tip for selecting the jewels.
F. Hollow tubes into which the jewels pass after selection and are carried to their respective containers.
G. High-power binocular microscope by which the jewel surfaces are examined for flaws before selecting for size.

CENSORSHIP prevents our disclosing Paul White's status and present assignment, but readers can tell from his previous contributions to *Instruments*, as well as from those in this issue, that he has solved inspection problems. Before the war he did practical as well as experimental work, in radio control instrumentation, flowmeters, etc.

The microscope he refers to is a high-power binocular instrument. We recommend this type for inspecting glass bearings. (Serious defects can be detected with a "shop microscope" but the inspector must have exceptional skill and exceptional eyes.) For inspecting jewel bearings on a full-time basis, some departments use elaborate equipment, including powerful oil-immersion-objective projectors with automatic feed and other automatic features which make inspectors' work easier and permit the inspection foreman at the same time to see the images thrown on the screen, to train new inspectors, etc.

Gone are the days of using only a needle to detect cracks in the vee cavities! —M. F. BEHAR

The importance of this procedure may be easily discerned, as the jewel screw must not bulge excessively after the jewel is set in it, which would easily be the case if it had not been previously checked carefully. The hole in the jewel screw itself is held very close to the size of the jewel it must receive, the difference being approximately 0.00075″.

By proper use of this selector, jewels may be graded on the basis of diameter and the screws drilled accordingly. The number of diameters is dependent on the economy involved. The savings may be figured on the basis of eliminating breakage of jewels caused by their diameters being

too large for the holes into which they are set, and eliminating troubles arising from jewels too loose because of their small diameters in relation to the hole in the screw.

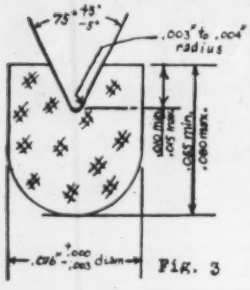

Fig. 3

Fig. 3 represents a sectional view of a glass jewel through the center. The jewels with which the writer is acquainted are manufactured to approximately the dimensions shown. (There are other more or less "standard" dimensions.) An endeavor is made by the manufacturer to adhere to these dimensions. However, strict compliance is almost an impossibility. Hence the need of grading by size to "save" a large percentage of production, with benefits to all concerned.

Notes on Visual Inspection Before Setting

A small needle (No. 10) in competent hands will detect roughness, pits, and other serious flaws. However, needle inspection alone will not reveal certain types of defects such as bubbles whose location make it necessary to reject the bearing. Therefore, microscopic examination is essential in addition to needle exploration.

Figs. 4 to 11 illustrate flaws which are prevalent in jeweled bearings and may be easily detected by the use of a microscope.

Fig. 4 illustrates small cracks which are found around the outer edge of the jewel and may cause complications and crushing when the bearing is pressed into the jewel mounting screw. Fig. 8 shows cracks radiating from the vee which the pivot will find as its bearing. These may cause a great deal of trouble if they are not rejected. Figs. 5, 6 and 7 show small bubbles in the bearing surface which ordinarily could not be detected by means of needle exploration but which can be seen by use of the microscope. The needle may be used to determine whether or not they will break through. Clusters and single bubbles below the surface may appear, and if they do not break through with the needle the jewel may be safely used. Fig. 11 shows two other types of defects: a malformed vee cavity and an off-center cavity.

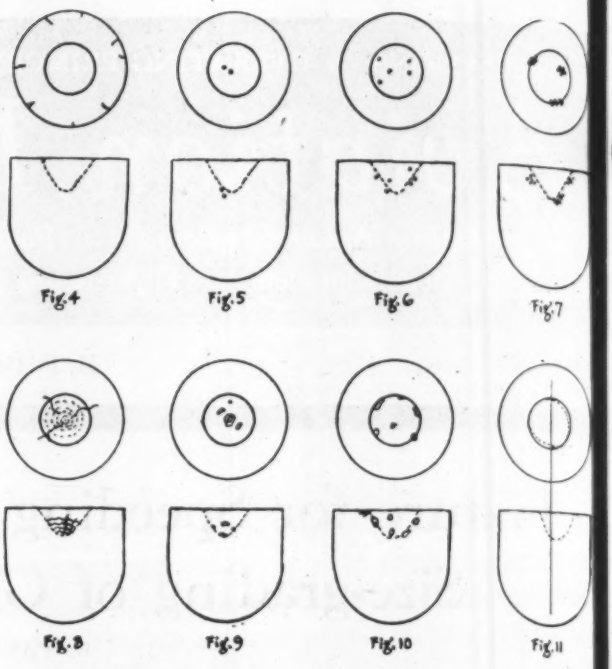
Fig. 4 Fig. 5 Fig. 6 Fig. 7

Fig. 8 Fig. 9 Fig. 10 Fig. 11

Inspection After Setting

After the glass jewel has been properly set in the jewel mounting screw it should again be inspected to see whether or not it may have been damaged by the setting process.

Some jewels may show evidence of chipping on their surface and it must be determined whether this chip may at any future time tend to progress toward the vee bearing cavity itself, which would be the cause for serious trouble to develop in the field where the instrument is in use.

If the chip does not cover more than approximately one-fifth of the surface and does not extend to the vee, the jewel is generally usable. However a great amount of skill must be developed to be able to determine usability.

Electrical-instrument "Exerciser" for Properly Adjusting End Play

By PAUL S. WHITE
2214 Main Street, La Crosse, Wisconsin

SETTING and maintaining proper clearance between jewel-bearing and pivot surfaces on electric type indicating instruments is a problem which has long been acknowledged as a "bugaboo."

If the clearance is not wide enough, the pivot becomes tight. The instrument might prove accurate and dependable under ordinary conditions, but when subjected to high and low temperature tests it will fail totally by reason of the expansion or contraction of the various parts which make up the bridge into which the jewel-bearing screw is mounted.

On the other hand, if the clearance is too wide, the instrument becomes sloppy in its performance and its indications may vary because of the pivot itself not seating properly in the jewel cavity but rather riding around the rim as illustrated in Fig. 1.

If proper care is not exercised in setting this clearance it becomes easily possible to distort the pivot point and to crush the jewel bearing or damage it to such an extent as to warrant rejection, or to cause the indicator to stick at various stages of the dial range. This condition in the jewel is shown in Fig. 2. Fig. 3 shows a bent or hooked pivot another example of the result of too much pressure.

The electrical jewel setting device described herein was

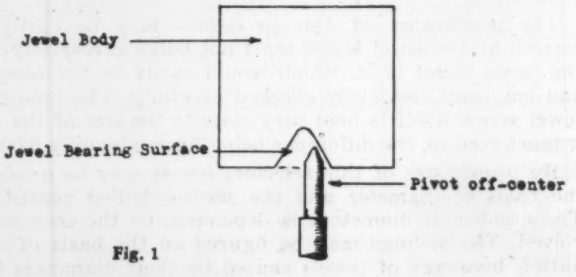

Fig. 1

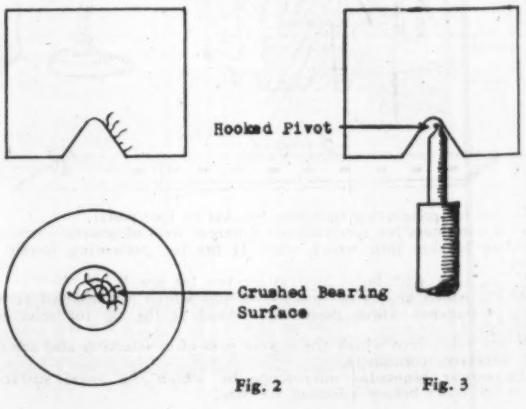

Fig. 2 Fig. 3

CANNON CONNECTORS FOR INSTRUMENT SERVICE

Here are just a few of the standard Cannon Connectors designed for instrument service. They represent part of the selection in the Cannon AN and K lines which instrument manufacturers are using in a wide variety of applications.

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Condensed Catalog Supplement gives quick review of the many types of Cannon Connectors. Request your copy from Department A-123, Cannon Electric Development Company, Los Angeles 31, California.

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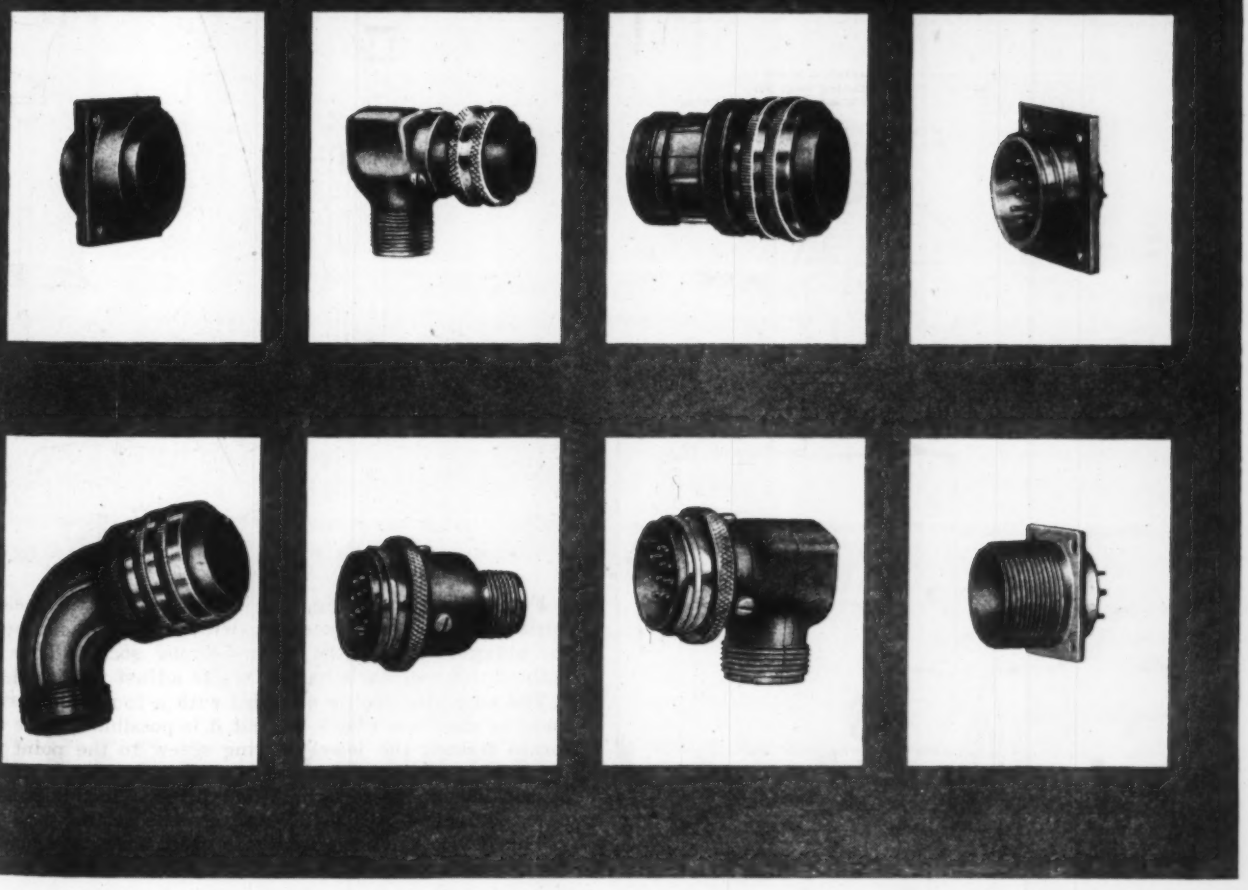
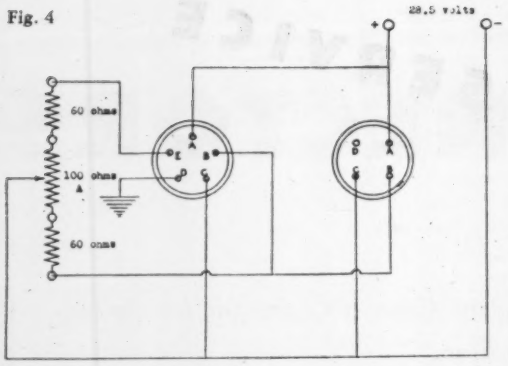


Fig. 4



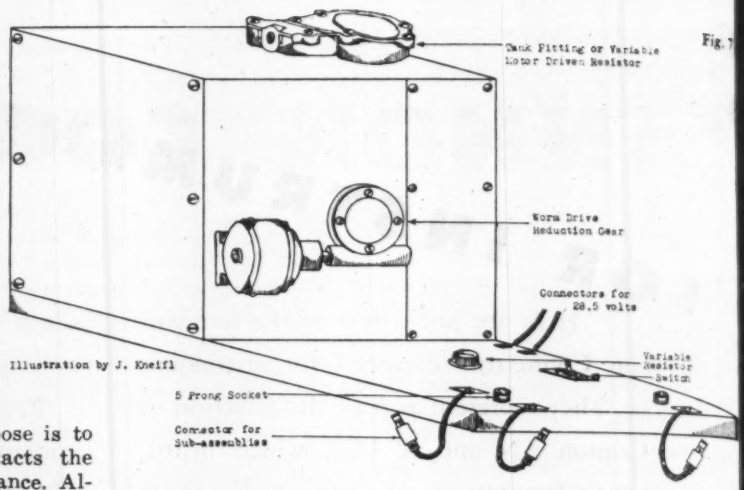

Tank Fitting or Variable Motor Driven Resistor
Worm Drive Reduction Gear
Connectors for 28.5 volts
Variable Resistor Switch
Illustration by J. Kneifl
5 Prong Socket
Connector for Sub-assemblies

Fig. 7

constructed from easily obtainable parts. Its purpose is to indicate the exact instant when the pivot contacts the jewel bearing surface during adjustment of clearance. Although it does not eliminate the human element in making the actual adjustment, its independent motor-driven rheostat is cut into the bulb or heater element and thus causes the pointer (which is operating under the instrument's own electric power) to make sweeping motions. The operator, while slowly turning the jewel screw by means of a jeweler's screw driver, carefully observes the slowly-oscillating pointer, which begins to slow down the instant its pivots come into contact with the jewel. The operator then backs off the jewel screw a predetermined amount. This assures that every indicating instrument will have the proper and same pivot clearance, regardless of whether the jewel be shallow, deep or odd-shaped.

Details.—The device makes it possible to control each jewel and pivot within 0.002" end play regardless of size or shape of the jewel.

By varying resistance *A* which is 100 ohms and which consists of an ordinary gasoline tank level transmitter with a 60-ohm resistance added to both sides, it is possible to swing the pointer of the instrument back and forth at a uniform speed.

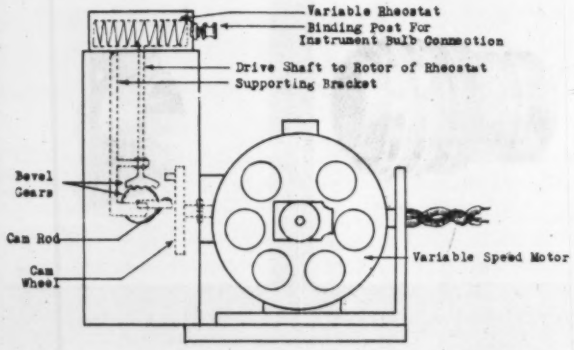


Fig. 5

Fig. 6

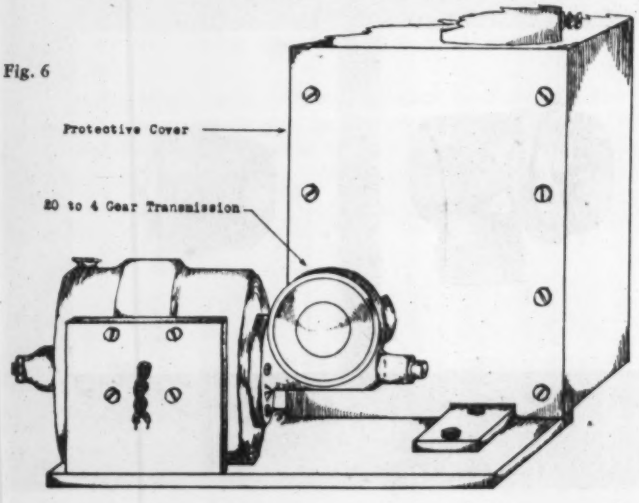
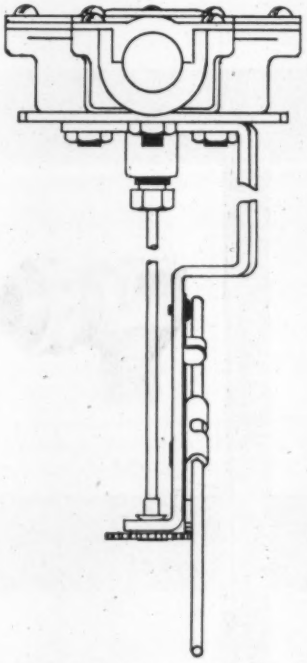


Fig. 6 is a schematic diagram which shows a variable-speed motor connected with an airplane float type liquid tank level transmitter, which has proved particularly adaptable to this application. A 20-to-4 ratio gear transmission operates the cam rod, which in turn causes the cam rod to move up and down and through bevel gears to rotate a movable rotor inside of the rheostat, which periodically varies the voltage flowing through the bulb circuit of the electrical indicating instrument.

The motor and worm drive reduction gear can be assembled from a commercial speedometer tester, thus allowing the complete apparatus to be built for little or no cost.



Commercial float-type gasoline level transmitter.

Fig. 8

Adjusting Tool.

Fig. 9

For ease in operating, the instrument may be held in a horizontal position, face up, with a receptacle provided for plugging it into the 4- or 5-prong socket. This leaves both of the operator's hands free to adjust the jewel screw.

The adjusting tool is provided with a four point arrangement as shown in Fig. 9, so that it is possible for the operator to tighten the jewel bearing screw to the point where the pointer of the instrument begins to slow down and then, by backing off the screw one-fourth turn (in this particular case, equivalent to 0.002") an accurate setting is assured.

This device has been used with great success in maintaining production as well as proper jewel clearance.

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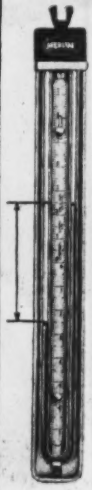

U-TYPE MANOMETERS

The Clean-Out Manometer for line pressures up to 100 lbs. per sq. in. A wing nut permits the Manometer body and tube to be disconnected from the head—the tube cleaned with a brush furnished or tube replaced, and the instrument reassembled without disconnecting the head section from the piping. Send for Bulletin No. 1.

The Model A-204 Manometer for line pressures up to 400 lbs. per sq. in. These instruments are built with heavy walled annealed straight Pyrex tubes, gland packed top and bottom in steel end blocks and clamped to the body at fixed intervals to prevent distortion. Bulletin No. 10 gives complete details.

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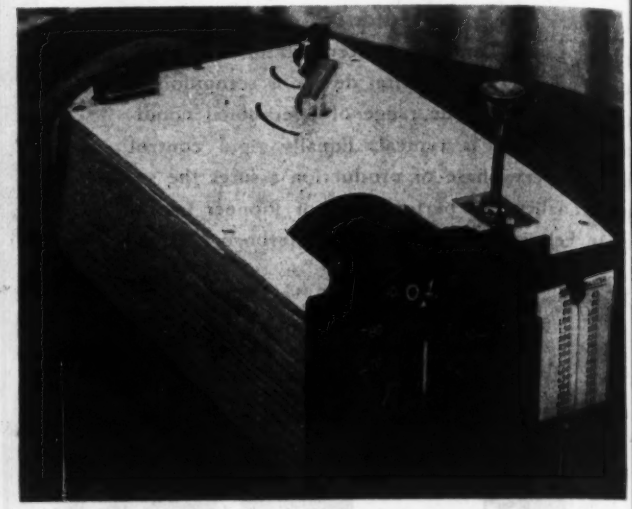
Airspeed Indicator Tester

By Cpl. JOHN G. NYEHOLT
14th Ferrying Squadron

TO facilitate the checking of Airspeed Indicators in aircraft, on large dispersal fields, without moving heavy test equipment and portable power plants to the ship, the tester shown in the photograph, made up by hand of assorted spare parts, has proven practical.

Using a Type F1 Pioneer instrument as a master, and a small syringe bulb, compressible by means of a screw, as a pressure source, a satisfactorily accurate check can



be made. To permit greater range than can be obtained by a single depression of the bulb and to take up the "slack" in the Pitot tube, a valve is put in the line so that built-up pressure can be held, while the bulb is released for a second or even third charge. Another valve, in a line from the bulb to the atmosphere, allows the bulb to expand again, refilling with air for these successive charges.

A scale error card for the Master Instrument is attached, so that by careful reading (tapping instruments gently) close check is possible. Great care should be exercised in assembling the valves and bulb, that no leaks are present. With an absolutely air-tight assembly, any leak in the Pitot line or the instrument under test will be immediately apparent.

In order to decrease pressure slowly (to prevent possible injury to instruments) after a test has been made, the bulb screw and valves should be used in reverse order as when pressure is being increased.

Trouble-shooting on the Gyro Flux-gate Compass System

By M. J. WIGGINS
Jacksonville, Fla.

FAILURE of almost any part of the Pioneer gyro-stabilized flux-gate compass system will cause non-operation. This complicates trouble-shooting as the ordinary "symptom-trouble" charts cannot be used. The only practical method of isolating the trouble is to check the resistances of the various units and cables, and the various voltages present under load. To obviate the necessity of breaking cables, disconnecting plugs and making haywire connections, the unit described herein was designed to permit all voltages and resistances to be measured at *one* point and in a matter of a few minutes. It greatly speeds up trouble-shooting.

In use, the four cables leading to the amplifier unit are

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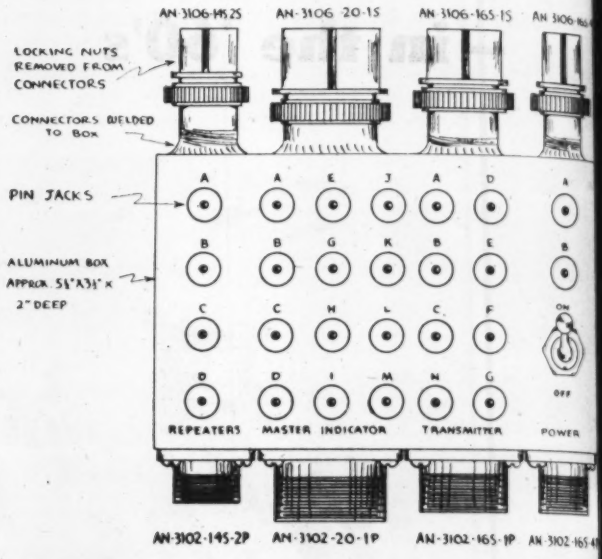
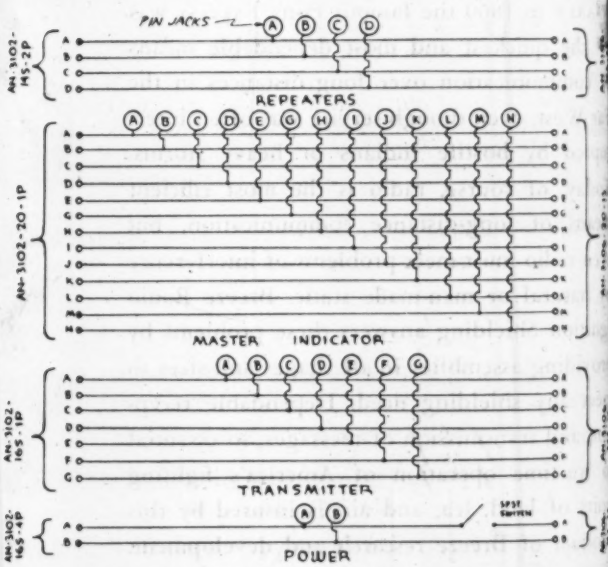
disconnected and the test box plugged into the four A connectors. The cables are then connected to the prop AN connectors on the test box. Inasmuch as the amplifi unit serves as a junction box for all the units, we no have all connections leading through the test box. The p jacks are lettered to correspond with the pins on the ca connectors. Using an a-c. voltmeter with a constant inp



impedance to about 1000 cycles and ranges of about 0-5 0-50, and 0-200 volts, the voltages across the various unit can be checked at the pin jacks. These voltage value should be within the tolerances as given in the technica orders on this system. By throwing the small toggle switc on the box to "OFF" and pulling the box out of the amplifie connectors but leaving the cables connected, all of the unit will be isolated from one another. The resistances of th various windings and cables can now be read at the pi



jacks. Any shorts or opens will be quickly found. Simi larly, by disconnecting the cables from the box and plug ging the box, by itself, into the amplifier, continuity through the amplifier may be checked, *Caution:* Use only an ohmmeter with a 1.5-volt battery as a higher voltage might cause damage.

There is one case of trouble in which all resistances and voltages will be correct but the indicator will read 180 de grees off. This is caused by improper setting of the phasing adjustment located on the deck of the amplifier unit. This

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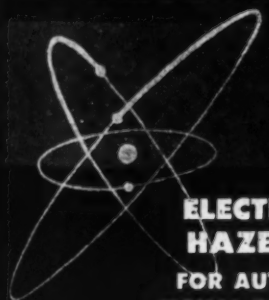

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adjustment controls the phasing of the variable phase and the fixed phase of the induction motor. The proper way to set this is with an oscilloscope. By connecting the master indicator jacks *I* and *J*, which are the variable phase connections, to the vertical sweep input of the 'scope and *G* and *H*, the fixed phase, to the horizontal sweep input, the phase relation can be checked by observing the figures on the screen when a signal is being received from the transmitter. A signal may be generated by having someone move a screwdriver back and forth near the transmitter. The phasing adjustment is turned until a circular pattern is obtained on the 'scope as signals come through. This is the correct setting.

The test box should be made of aluminum to allow the aluminum AN connectors to be welded directly to the box as shown in the sketch. Care should be taken to have all connectors lined up properly so that they will slide easily into the plugs on the amplifier unit. The coupling nuts are removed from the connectors as it would be difficult to screw them onto the plugs. The tip jacks are the radio type with colored tops. By using different or alternate colors for the groups of jacks, it will be easier to find the proper plugs. It will be noted that jack *N* of the Master Indicator group is found in the Transmitter group. This was necessary for symmetry. Prong *F* on the master indicator is vacant so it was left off. The small single-pole single-throw toggle switch in the power leads was included for convenience.

AIRCRAFT INSTRUMENT GUILD

INTERNATIONAL HEADQUARTERS — 812 N. DELAWARE PLACE TULSA, OKLAHOMA

The following articles have been contributed by the Aircraft Instrument Guild. For further information on any of the subjects discussed, write to the Guild at the above address.

C.A.A. Ratings for Aircraft Instrument Mechanics

By R. G. OJERS, Guild President

ONE of the major projects of the Aircraft Instrument Guild—a project which was undertaken for the benefit of all instrument mechanics—is now showing signs of bearing fruit. We now have reason to hope that instrument mechanics will be recognized by the Civil Aeronautics Administration and that ratings will be given according to qualifications and skill.

We were recently honored by a visit from Mr. O. E. Patton, Instrument Unit, Aircraft Engineering Division, CAA. Mr. Patton stopped here especially to investigate our activities; and he was well pleased. Our program and progress interested him most, as he was just finishing a tour of all the major airlines and repair bases, gaining information regarding the revision of all mechanics' ratings and the rating of instrument mechanics.

On this trip he had contacted department heads and foremen, myself included, regarding our opinion of the minimum qualifications for issuing a certificate to an instrument mechanic.

From my own years of experience as an instrument mechanic with a large airline and from the opinions gathered from fellow mechanics, supervisors, foremen and execu-

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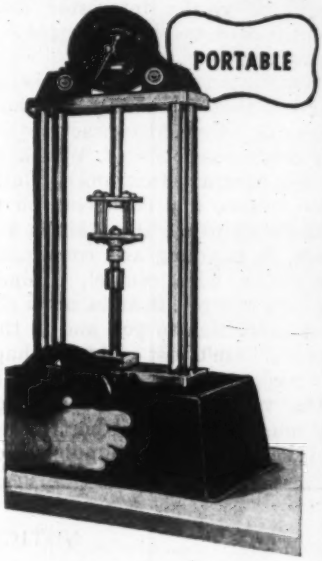

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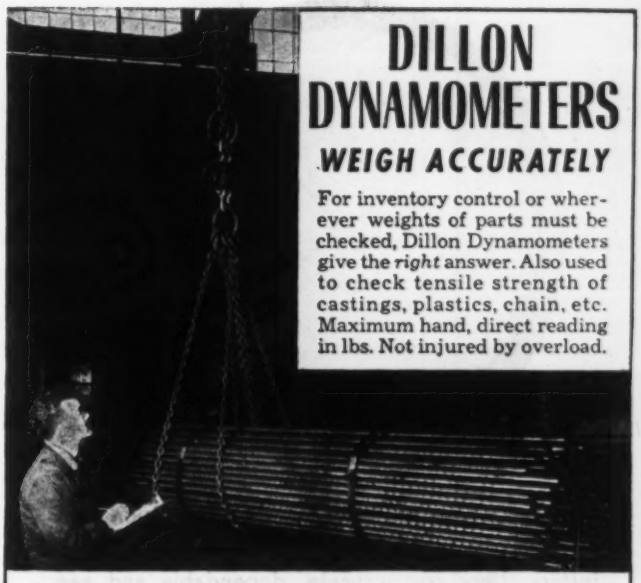

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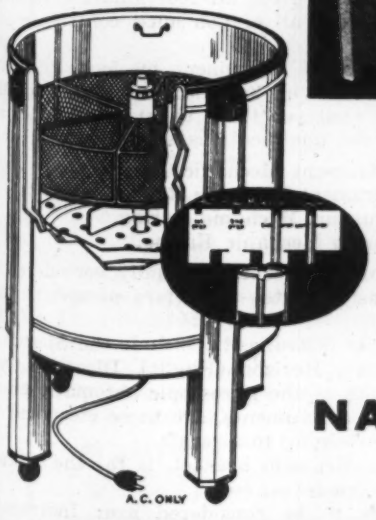

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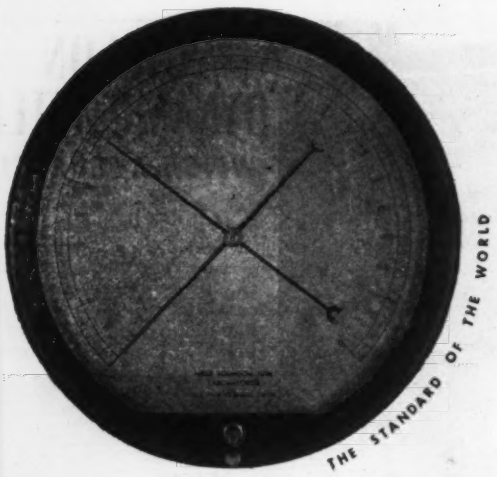

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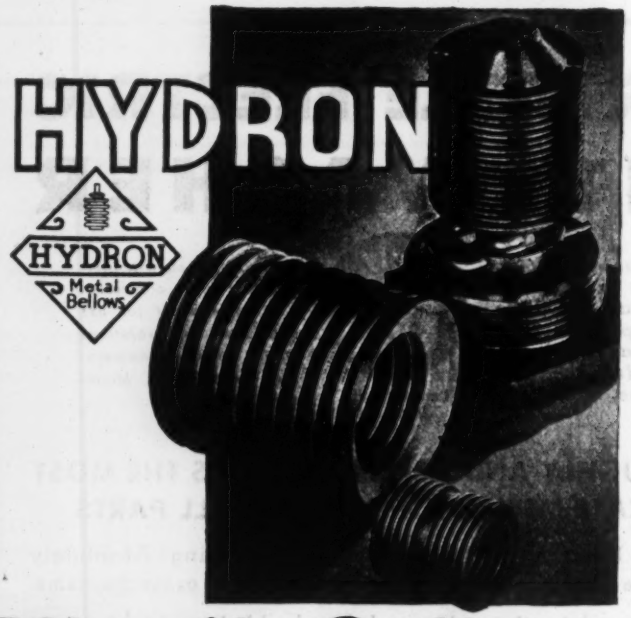

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tives working in factories, airlines and Civil Service Depo —and on behalf of the more than 300 mechanics who grad ated from Spartan under my supervision—I assured M Patton that the great majority of instrument mechani would be vitally interested and I told him that con quently *each mechanic should be given the opportunity express his own views.*

Mr. Patton thought this also a good idea and he recom mended that we obtain opinions from every instrume mechanic we could contact, either through the Guild or any other possible way. Whether or not you are a memb of the Aircraft Instrument Guild, we should like to hav *your* opinion and comments on this idea.

It seems to me that this is a great opportunity for ou trade. It is young and consequently should be under som control—a wise control, a limited control, above all, friendly control. Bear in mind also that such control woul be a protection to you and to the trade. Perhaps the wor "control" isn't just right; perhaps the ideal is "regulation or "recognition" . . . YOU can help shape our future.

Our trade is now going through its early growing pain We must all pull together to see that it is properly guide and kept from unscrupulous influences. The Civil Aer

NOTICE

Some of our members have moved from the original addresses submitted to your Secretary and have become lost. We must have your correct mailing address in order that your name may be supplied to various instrument manufacturers to receive their information material. In addition, since your magazine *Instruments* is sent by second-class mail, it will not be forwarded unless we or the publishers are notified.

Soon we will have ready at no cost to members a fine leather identification case to be carried either in a pocket or under your belt. The outside flap has a place for your identification badge and immediately below this is our Aircraft Instrument Guild insignia stamped in gold and silver: an article instrument mechanics will be proud to own and display.

Hence the necessity of our knowing your true present address.

A. J. PFISTER,
Secretary, Aircraft Instrument Guild.

nautics Administration has done wonders in guiding and regulating civil aviation. We as a part of civil aviation will certainly benefit by such guidance and regulation.

The Aircraft Instrument Guild can assist *each* of you individually by combining the efforts of *all* of you for this purpose. Our trade is now so specialized that we must have complete information from all individuals concerned. A few replies will not do; all of you must contribute and help.

This is an appeal to *all* instrument mechanics to give their opinions on the following summary submitted by Mr. Patton. Let us know what you think about this breakdown and what you think the qualifications should be for each:

A. *Mechanical* Instrument Mechanic Rating.
B. *Gyroscopic* Instrument Mechanic Rating.
C. *Electrical* Instrument Mechanic Rating.
D. *Optical* Instrument Mechanic Rating.

The A, or mechanical bracket, is usually considered to consist of standard instruments—altimeters, airspeeds, turn and banks, etc.

The B, or gyroscopic instruments, include the Sperry or Jack & Heintz Auxiliary Horizon (Flight), Direction Gyro (Turn), and both units of the gyroscopic automatic pilots.

The C, or electrical instruments, are those electrical instruments directly pertaining to aircraft.

The D, or optical instrument bracket, is for the octants, sextants, driftmeters, cameras, etc.

Two other ratings to be considered are: instrument

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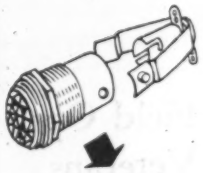

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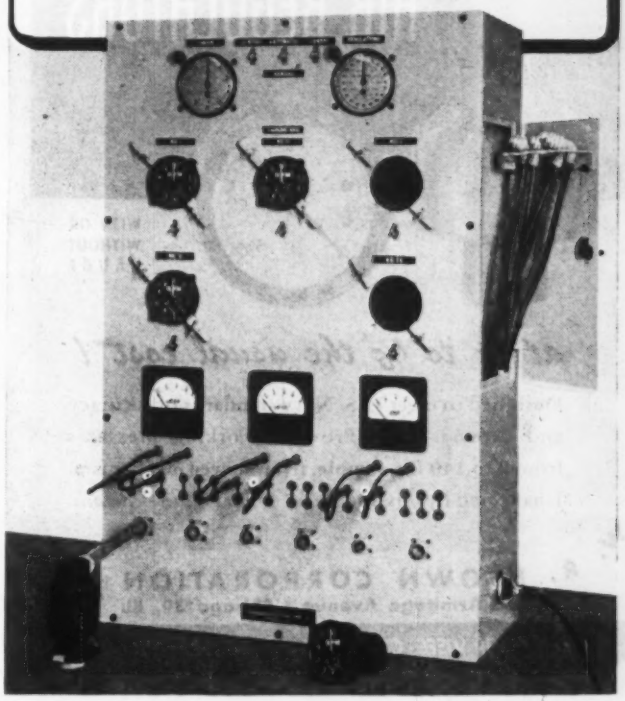

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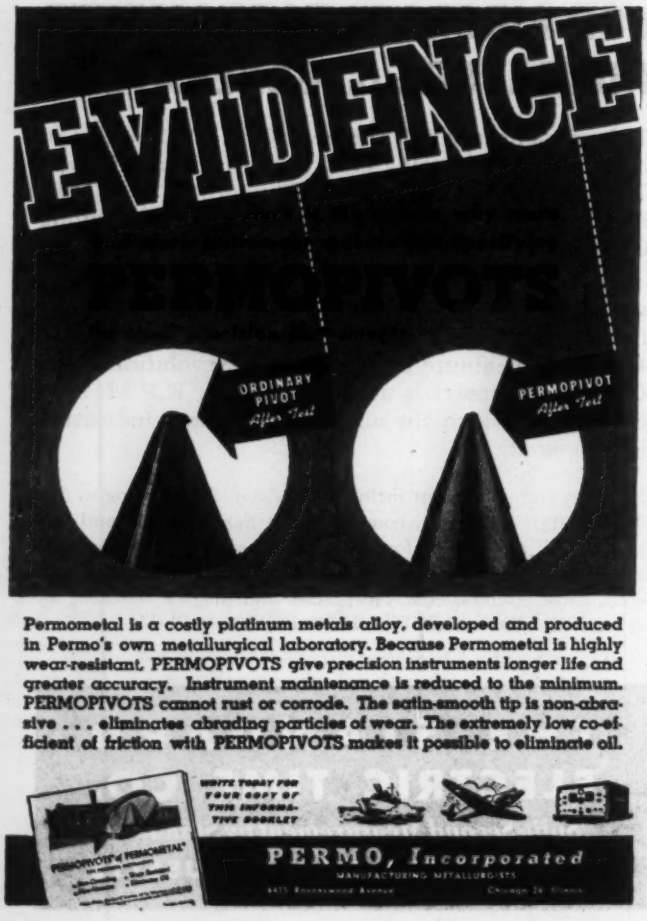
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maintenance, covering installation and removal, line che trouble shooting, etc.; and the instrument *instructor* rati which is due for a revision and should be seriously co sidered.

What, in your opinion, should be the requirements? P down your views in detail, preferably typewritten (but ne handwriting will do). First give your *general* opinio then use the above letters A, B, C and D, also M f maintenance and I for instructor, as headings for the se tions of your letter. Discuss only one or two, or discu all—but *send in your opinions!* Address me at 812 Nor Delaware Place, Tulsa, Oklahoma. Do it now!

R. G. OJERS

President, Aircraft Instrument Gui

Aircraft Instrument Field Open to Disabled War Veterans

ONE more service the Aircraft Instrument Guild glad to work on to the best of its ability, is to he our returning war veterans whenever we possibly ca whether they are members or not. A card from Barn Kates of 535 Kingston Avenue, Brooklyn 25, New Yor reads as follows:

I am a disabled veteran of this war with a total loss of hearin I am now taking lip reading instruction to overcome this hand cap. Since I spent 2½ years in the Air Corps both in weather a radio and know both theories very well, I have been thinking undertaking training for Aircraft Instrument Mechanic. I ha been given to understand by the school that hearing is not esse tial in pursuing this trade. I also have sent requests for inform tion to Civil Service, Aircraft Transport Company, Aircraft Co struction Company and an instrument company for advice co cerning my possibilities of gainful employment with my handic It seems my requests were overlooked in all cases and have n received any reply. I would be extremely grateful to you for a vice regarding this contemplated training. I held the Chief Obser er's post at Barksdale Field, U. S. A. Air Corps, studied ra pre-service and in service and know my electronic theory we well. Please advise. Thankfully yours, Barnet Kates.

For the benefit of this veteran and others so disabled th they are unable to get back into their own field of endeav (and others that were taken directly from school witho having an opportunity to learn a trade) a special boa has been created by the government. The Veterans Admi istration has a department to rehabilitate disabled soldie so they may learn a trade and pursue a gainful occupatio The cost of this schooling is paid for by the Veter Administration.

The disabled veteran can, within reason, choose the tra he desires and that will fit in with his handicap, whether is in the field of aircraft instruments or any phase of t aeronautical industry, or any other field such as watc making, salesmanship, farming, drafting, merchandizi automobile repair, etc.

The Aircraft Instrument Guild takes this opportunity welcome you into our trade, and do everything possible help you get started, realizing that this is a field whe many disabled veterans may find suitable work.

Through the activities of the Guild we will attempt set up a department to answer all questions possible r garding training in aircraft instruments as well as plac and opportunities for employment after such training h been completed. The latter is a service we have alread started for our present Guild members and it has prov beneficial.

With regard to Veteran Kates, so many details were le out of his inquiry that it is difficult to give him much *speci* help. This may be the reason he did not receive replies t his previous requests. (Surely, no American industrial o ganization would entirely disregard a request for inform tion such as he submitted. Probably, inexperienced mai desk clerks were at fault.) If you want any informatio regarding possible employment, we suggest that you ado the following method: In order to have a guide for the co rect information to give a prospective employer, obtain fr your nearest postoffice a Civil Service application blan Copy the essentials of that form on a typewriter and the

DEW POINT TESTER

THE R.S.C. TULSA — SERVICE ACCURACY

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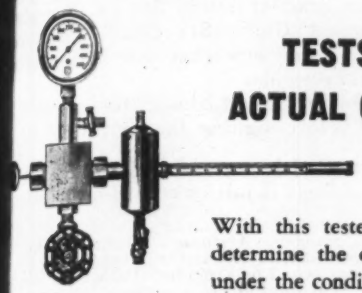

TESTS UNDER ACTUAL CONDITIONS

With this tester it is possible to determine the dew point of gases under the conditions of pressure as they exist. Through the combined use of a refrigerant and a special stainless steel mirror dew points of gases are determined with an accuracy of 0.2° F. Suitable for working pressures up to 2500 P.S.I. and dew point temperatures as low as –90° F.

Catalog No. 26

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use your copy as an application form, being sure to fill it out completely and carefully. On an added sheet of paper give a full description of your disability. It will be a definite help also to enclose a copy of an opinion from a reputable doctor that you are fit to do this type of work. Mail these to the director or registrar of the school in whose course of instruction you are interested. Mail copies also to the companies with which you would like to be employed when you have completed your training. Send a copy also to the Aircraft Instrument Guild, 812 North Delaware Place, Tulsa, Oklahoma. I am sure that you will receive informative replies from everyone.

When choosing a school for your training, be sure to investigate its reputation before signing the contract.

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Instruments in the War Effort

Supervisory Instruments Avoid Turbine Troubles and Help Train New Operators

HOW the proper application and use of turbine-supervisory instruments promote efficient operation and prolong the life of power-generating equipment was described in a recent ASME paper by J. L. Roberts, of General Electric's Turbine Engineering Dept., and H. M. Dimond, of the Company's General Engineering Laboratory. They described how one large power company makes a practice of keeping a file of photostat copies of all starting sequences on their turbines in a size convenient for record book or file. These records and an accompanying brief "case history" have not only proved invaluable in the study of turbine performance, but in the training of new operators as well, they pointed out.

They cited cases where turbine supervisory instruments had detected conditions that might have resulted in the failure or considerable destruction of important power-generating machines if they had not been found and corrected.

For example, eccentricity records on the performance of a 40,000-kw. turbine led to the discovery of several broken buckets in time to prevent the extensive damage that probably would have resulted.

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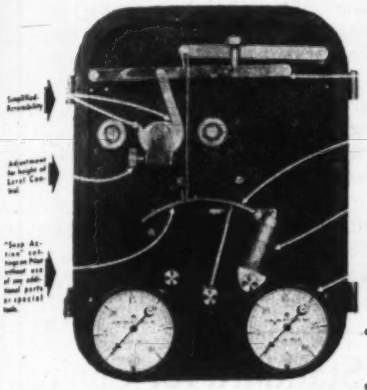

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"Princo" MERCURIAL PYROMETERS are available in ranges up to 1200° F. and are made in a variety of sizes and stem lengths.

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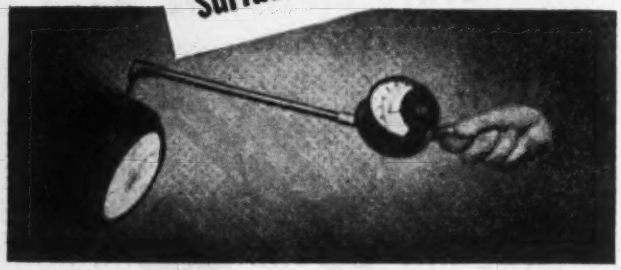

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recorder indication, the crack could have progressed until complete failure resulted because the vibration increase was so gradual that it went unnoticed.

Supervisory instruments used in starting an 80,000-kw. turbine prevented wear on packings and bearings that would have decreased efficiency of operation. By indicating the conditions of the machine during the starting sequence, the instruments told the operators how much time to allow for working out excessive eccentricity and vibration.

Turbine supervisory instruments consist basically of an appropriate detector or detectors mounted at the proper location of the turbine-generator set, and a power unit and recorder mounted on a panel near the operating board. They reported that about 80% of the large G-E turbines now installed are being provided with one or more of the instruments. The instruments record turbine conditions in terms of shaft eccentricity, bearing vibration, shell expansion, speed, and camshaft position. A non-recording interference detector is also available.

Commercial Standard for Clinical Thermometers

IN the third edition of *Clinical Thermometers, Commercial Standard CS1–42*, the revised requirements are somewhat higher than those of the previous standard, so that certain thermometers which would previously have been acceptable would now be rejected. The standard provides also that records of test results shall be kept on file by the manufacturer for at least two years after the tests were made. The standard covers materials, construction, and aging. It also prescribes in detail, methods for testing, such as a test for the pigment in the graduation marks; a test for entrapped gas in the bulb and mercury column; a test for difficulty in shaking the column down before using (hard shakers); tests for accuracy; and a test for retreating index. Copies of *CS1–42* are obtainable from the Superintendent of Documents, Government Printing Office, Washington, D. C., at 10 cents each.

Revised Handbook on Weighing and Measuring Devices

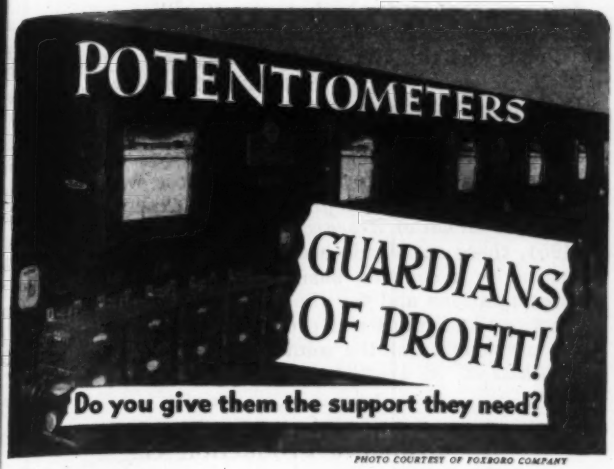
REVISED specifications, tolerances, and regulations for commercial weighing and measuring devices are set forth in *Handbook H29*, just released by the National Bureau of Standards. This revised edition incorporates all changes adopted by the National Conference on Weights and Measures and recommended for promulgation by the States, since the publication of H22 in February 1938.

In providing for subsequent revisions, the new Handbook is arranged on a different plan from the old one. Instead of attaching all correction sheets to stubs at the back of the book, two or three blank pages are inserted after each of the several codes of specifications, and on these pages any corrections can be pasted, thus grouping related material and making the book handier to use.

The publication of H29 is of particular interest at this time because certain of the recommendations of the National Conference on containers, scales, etc., are being incorporated in various WPB Limitation Orders. The price is 60 cents a copy; orders should be sent to the Superintendent of Documents, Government Printing Office, Washington, D. C. The Handbook is bound in buckram.

Provisional pH Standards

THE efficiency and rapidity of many processes involved in the preparation of commercial products depend upon the accurate control of the acidity or alkalinity of aqueous solutions. Such control is now a legal requirement in certain medicinal preparations, in the manufacture of paper and leather for the Government, and in many Federal speci-



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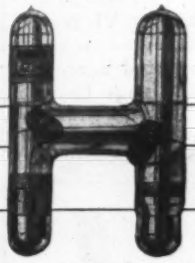

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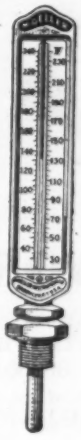

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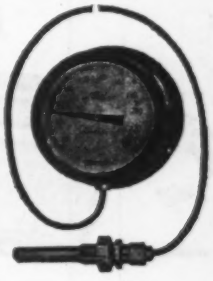

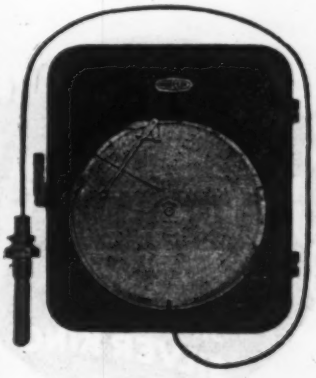

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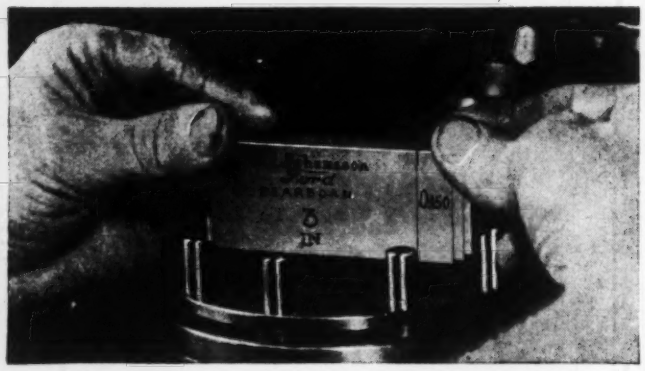

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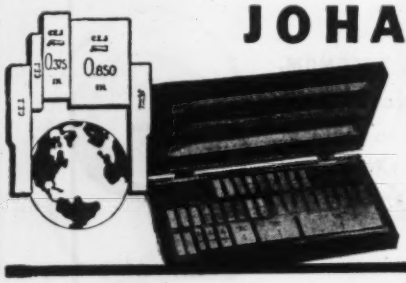

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fications. Products valued at over 40 billion dollars are m ufactured annually under conditions of controlled acidi

Roger G. Bates, Walter J. Hamer, George G. Manov, a S. F. Acree, of the pH Standards Section of the Natio Bureau of Standards are engaged in devising and impr ing methods for the accurate measurement of acidity have recommended 17 standard solutions of a wide ra of known acidities for the use of those workers who n to determine pH with precision. As explained in the S tember *Journal of Research* of the Bureau (Research Pa 1495), these standards are intended to be employed in justing to a common basis equipment now in use for determinations and for the control of acidity in laborat reactions and industrial processes. Directions are given the preparation of the solutions, and the pH values at 2 25°, and 30° C are listed.

Ordnance Production Gaging

Continued from page 669

dropped from the center of the higher roll perpendicular the surface plate) the angle may be determined accurat (within several seconds) from the difference between heights of the rolls or buttons.

Of the two, the sine block shown in Figs. 30 and 31 a the sine bar shown in Fig. 6 of Chapter VI, it will usua be found that the sine block is preferred to the sine b The sine bar must usually be supported against an an plate since it will readily tip off the gage blocks if not

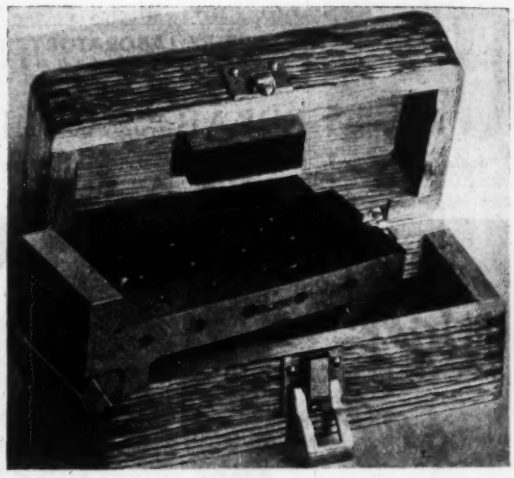


Fig. 30. A 5" sine bar in case. (Taft-Pierce Mfg. Co.)

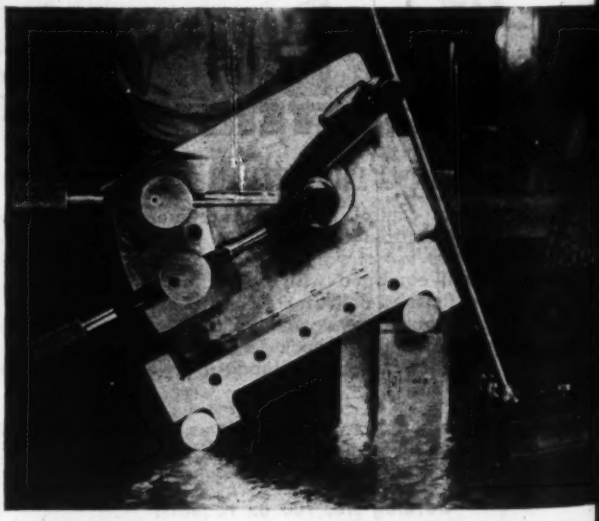
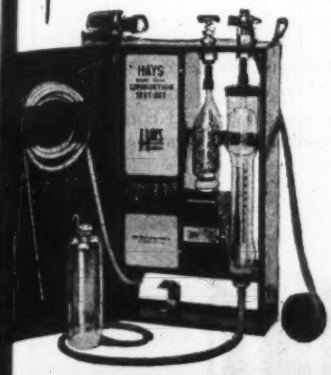


Fig. 31. By varying the gage blocks supporting the sine block, the p tion of the pin may be varied until the pin is level and the angle o sine block calculated. The same procedure may then be used to deter the angle of the sine block when the other pin is level, and the differ between these angles will be the angle between the two pins.

STOP! THOSE DOLLARS POURING OUT THE STACK...

Do you *know* the CO_2 content of your flues? Do you *know* the facts about draft? Why not find out? That's easy with a Hays Combustion Test Set—it tells you the whole story in a jiffy; may easily save many times its modest cost by immediate fuel savings and vastly increased efficiency. It's a practical combination of the Hays Gas Analyzer—the fastest known—and the Hays Pointer Draft Gage — the pioneer dry type gage.



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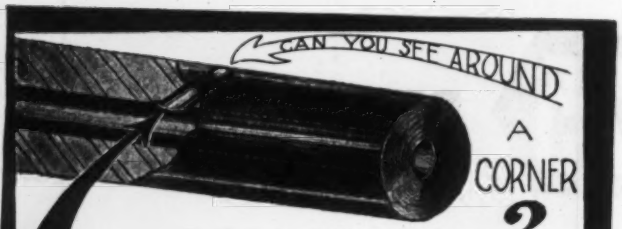

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supported. The sine block, on the other hand, having a longe line of support, will rest steadily on the surface plat Further, the sine block has been designed in order tha gages may be laid on its surface and tipped to the angl desired without actually being fastened to the block.

Special care of sine blocks and sine bars—Because of mag nification in this type of measurement, the slightest scratc or burr on the rolls or surface of the sine block or th buttons or straight edges of the bar will cause serious in accuracies in the angular measurements. When burrs an scratches do occur, they should be stoned off only by some one thoroughly familiar with the accuracy which is expecte of these instruments.

GROUP XII

Optical Comparator.

Probably the greatest controversies relative to the equip ping of the gage laboratory revolve around the question "Are we or are we not to have an optical comparator, an if so, what type and how accurate?" The reason for thi

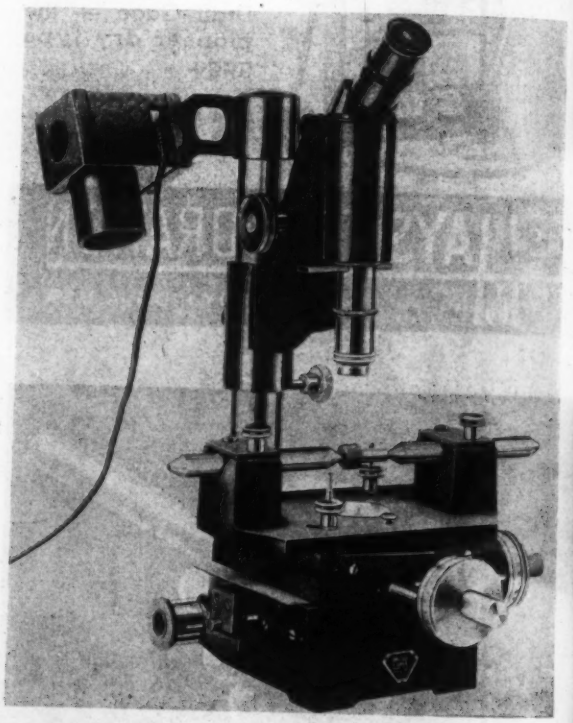

Fig. 32. A toolmaker's microscope being used for the inspection of the lead, form and angle of a thread. (Bausch & Lomb Optical Co.)

is probably due to the cost, because if the supermicrometer and/or comparator are chosen in Group III instead of measuring machines, an optical comparator of the same degree of precision may itself cost more than all the re maining equipment put together.

The solution of this problem must again be based upon the work to be done. The following general rules will apply:

1. A gage laboratory cannot be *self-sufficient* without an optical comparator.

2. For greatest efficiency, the accuracy of the comparator should be comparable with the accuracy of the other equip ment in the Laboratory. A highly skilled operator who has a knowledge of optics and who has become thoroughly familiar with the instrument may be able to acquire accu racies of 0.0002″ to 0.0003″ with a comparator whose accu racy is rated to 0.001″. However, this represents consider able waste of highly technical skill.

Optical comparators can generally be divided into two

How to FIGHT "BULLS" that come from careless counting

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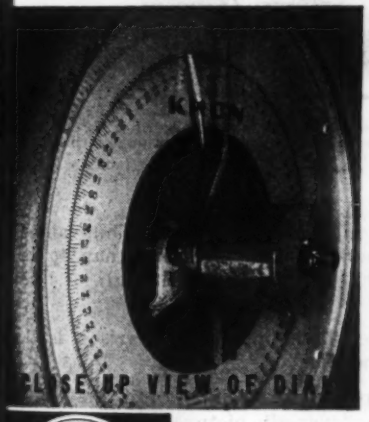
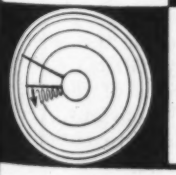


CLOSE UP VIEW OF DIAL

"Magna-Pointer" held at zero before timing interval.

"Magna-Pointer" engages and moves with weigh pointer during interval.



"Magna-Pointer" instantly stalls at end of timed interval.

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Permits accurate "rate of flow" indication for timed intervals. It is a perfect automatic tare device for barrel, box or bag filling. It is invaluable for mixing chemicals or fluids.

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AUTOMATIC TEMPERATURE CONTROL COMPANY, INC.
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classes: Those in which the part itself is viewed through a series of magnifying lenses, and those in which the image of the part is projected onto a screen. The former type, which includes ordinary microscopes and toolmakers' microscopes (Fig. 32), is principally used for examination of thread forms, surface accuracies, etc. Standard outlines, cross hairs, etc. are furnished with toolmakers' microscopes for the determination of angles, but odd-shaped images cannot usually be readily measured. The screen type of comparator (Fig. 33) is much more universal in that if an odd shape is to be checked, it may be drawn on a magnified scale, placed on the screen, and the outline of the gage projected against it.

If threads are to provide the greatest bulk of the work, and if the remaining shapes to be measured are simple, a

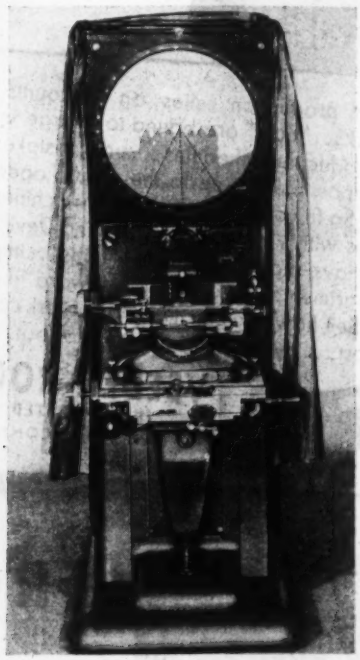


Fig. 33. An optical comparator showing the image of a thread on a screen. The thread is being checked for lead, form and angle. (Bausch & Lomb Optical Co.)

toolmaker's microscope might be sufficient. While almost any shape may be measured by other means than optical comparison (see Chapter VII on Profile Gaging) three conditions obtain:

1. Occasions will arise when optical comparison is the only means of measurement;

2. On complicated shapes and especially radii, the optical comparator will give an "over-all picture" rather than a point-by-point determination; and

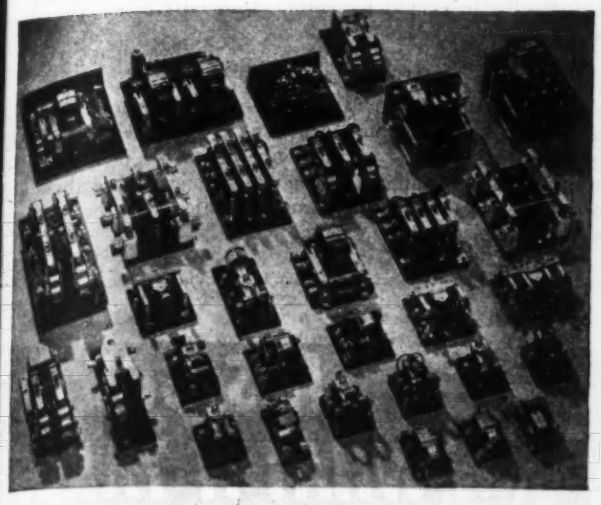
3. If a profile is complicated, considerable time and skill will usually be saved with an optical comparator of the screen type.

Special care of optical comparators—Other than ordinary care that should be afforded any delicate instrument, special care will be prescribed by the manufacturer of the particular instrument which is procured.

Group XIII

Straight Edges and Precision Squares.

Straight edges and precision squares provide the laboratory working complement of the master cylindrical square discussed in Group II. Particular descriptions of their use need not be made as their use is normally obvious. They require no special care other than the usual prevention of burrs and scratches. Precision squares should, however, be



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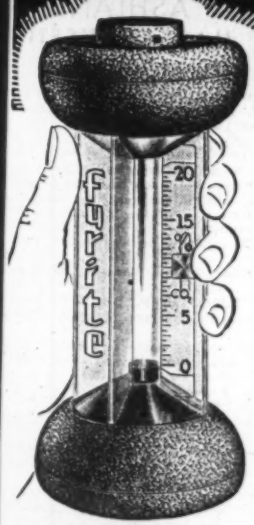

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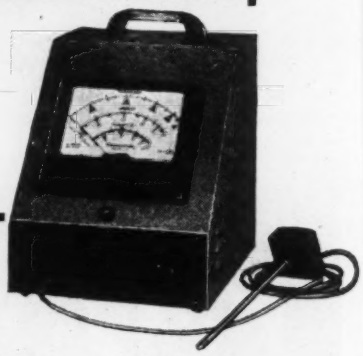

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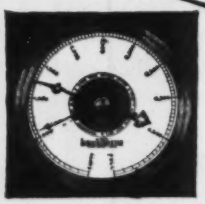

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Other Laboratory Aids

Many other instruments, used in the laboratory for saving time and increasing accuracy, are not here considered to be essential. Some of these are hereafter pictured without particular comment. It should be noted that these are by no means all the instruments which may be used, or even a representative group.

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State of Pennsylvania, County of Allegheny, (ss).

Before me, a Notary Public in and for the State and county aforesaid, personally appeared Richard Rimbach, who, having been duly sworn according to law, deposes and says that he is the Publisher of *Instruments* and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation) etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, as amended by the Act of March 3, 1933, embodied in section 537, Postal Laws and Regulations, to wit:

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Publisher, Richard Rimbach, Pittsburgh, Pa. Editor, M. F. Behar, Pittsburgh, Pa. Managing Editor, Richard Rimbach, Pittsburgh, Pa. Business Manager, Richard Rimbach, Pittsburgh, Pa.

2. That the owner is: (If owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding one per cent or more of total amount of stock.)

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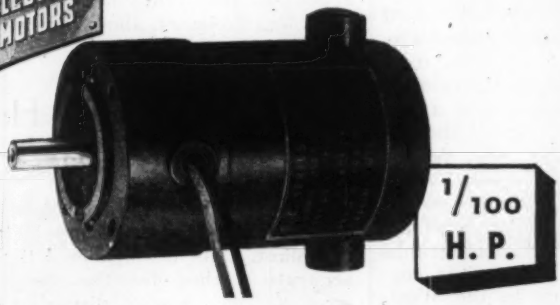

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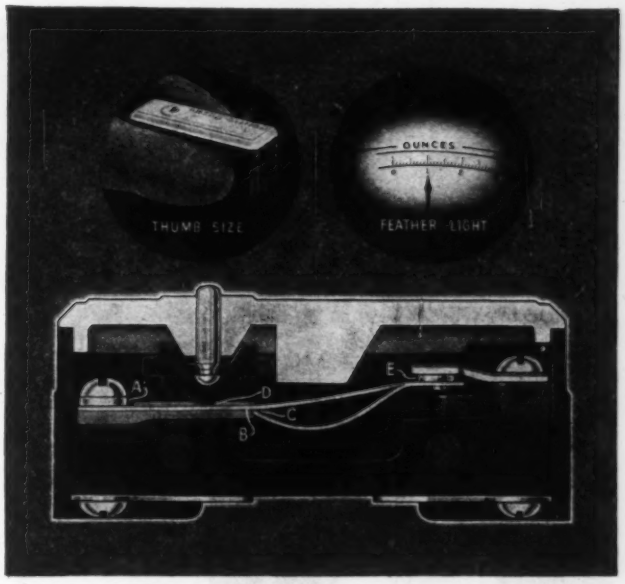

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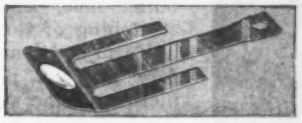
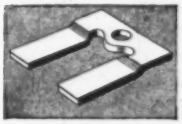
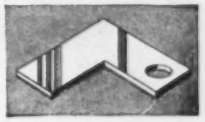
The Micro Switch design incorporates features that provide desirable performance characteristics not generally found in snap-action switches . . . The heat-treated beryllium-copper spring bends in the same direction as the operating plunger—no reverse bends—no "oilcan" action . . . gives longer switch life—accurate repeat action —increased contact pressure—lightning-fast action—millions of operations on minute movement and force differentials. It is the choice of design engineers for all types of sensitive instruments.



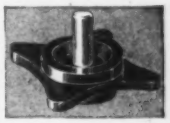
The beryllium-copper spring is made in one piece. It is gauged to an accurate .0085" thickness; has high resistance to fatigue. Ends of compression members are finished to provide an extremely low friction bearing. Contact end of the spring is fitted with a riveted radius type contact of 99.95% fine silver. It moves at a speed of 3/1000ths to 5/1000ths of a second with a rolling action and extremely high pressure.



Short spring members pivot in patented V-grooves of this sturdy brass anchor. Note the special shape of these grooves, which reduces friction to a minimum.

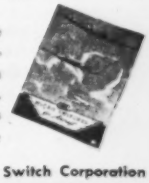


Stationary contact is a flat inlay of 99.95% fine silver. This construction assures ample over-load capacity and maximum heat dissipation.



Operating plunger is a highly polished stainless steel pin imbedded in an accurately moulded star-shaped Bakelite head. Provides long over-surface path to live parts, thus insuring freedom from electrical leakage. Plunger head cannot rotate within the housing, insuring against any variation in point of operation.

If you would like to know more about the Micro Switch, send for the two Handbook-Catalogs illustrated here—No. 60, which covers Micro Switches in general; and No. 70 which deals with specific Micro Switches for use in aircraft. © 1942



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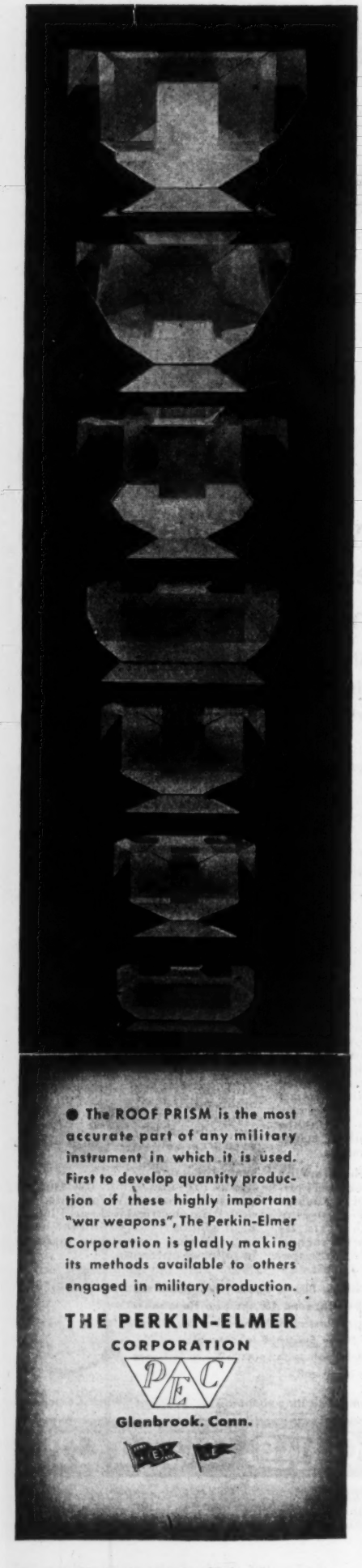
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Instruments in the War Effort

Brittle-coating Method Aids Development of Armor and Armor-piercing Bullets

THE lacquer-held "footprints" of a bullet crashing into steel plate are giving research men new information which may aid in the development of tougher armor and better armor-piercing shells for the nation's fighting men. The "footprints" are thin, closely spaced cracks which appear on a lacquer-coated steel target under the impact of a speeding bullet. The method was described in *Instruments*, April 1939, by Professor A. V. deForest in an article illustrated with perhaps the most effective magnified photographs published. Dr. Miklos Hetenyi is conducting the experiments in the Westinghouse Research Laboratories. Some shots fired in the laboratory create a heart-shaped pattern extending 6″ or 8″ from the spot where the bullet hit or penetrated. In other tests the cracks form a series of circles around the bullet hole. Each tiny crack denotes stretching of the metal underneath the uniform-brittleness lacquer and therefore gives a permanent quantitative picture of the strains that occurred at the instant of impact. By spraying this uniform-brittleness lacquer coating known as 'Stresscoat" on metal parts and then contorting them until the brittle skin cracks, Dr. Hetenyi and other Westinghouse research engineers can also detect vulnerable spots in gears, shafts, valves and other parts of vital wartime equipment. In popular explanations which were printed in many newspapers and even in industrial journals, it was stated that "just as yawning crevices opened by an earthquake reveal faults deep underground, tiny fissures in the lacquer tell a story of the strains that machine parts experience," but the value of the method lies in the *uniformity* of the brittleness.

In one test Research Engineers William E. Young and John J. Gertz put the lacquer coating on a 1600-lb. model of a gear tooth and squeezed the tooth in a large hydraulic press to locate accurately the stresses. Results of their work were turned over to the Nuttall Gearing Works of Westinghouse which is manufacturing gears for submarines, subchasers, etc.

Lacquer sprayed on the gear toot dries in 15 hours to form a tight clinging skin about as thick as th diameter of a human hair. To dete mine the minimum strain that will cra this coating, a foot-long homogeneou steel bar is sprayed at the same tim as the gear tooth and under the sam conditions. After drying, the steel b is subjected to a cantilever bendin test. Most of the cracks in the coatin appear at the rigidly-held end and b come less frequent, thereby permittin calibration.

Gaging Teeth of Hug Marine Gears

PIN-CHECKING a large marine pr pulsion gear at a General Electri Co. plant. This is considered the mo accurate method for the checking gear cutting. A high degree of acc racy is maintained in gear cutting, bu

as a further check the teeth are meas ured on both helixes by the pin-check method. The gear is rotated slowly, an the operator inserts a hardened pin i the space between adjacent teeth. A the gear rotates, the pin bears on th lever and gives a reading on how fa the pin drops in between the teeth

eadings are plotted and analyzed to eck tooth spacing and accuracy for noother operation. "Tooth spacing ust not vary more than three-tenths f a mil, or about one-fourth the thick-ess of a cigarette paper."

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een trained in test work and are ex-ertly using various types of instru-ents. While her husband serves as . S. Navy petty officer, Doris Grozik, rmer top Chicago model, puts air-aft carburetors through performance sts in an "air box" which simulates tual flight conditions at the Bendix viation Corporation's Illinois division, hicago.

Modified Shop Instruments Speed Measurements

TWO more War Work Speed-up ideas, both consisting in modify-g shop instruments to minimize the me of measuring, inspecting, tool-tting, etc., have been disclosed by the eneral Electric Co.:

Modified Indicating Gage. This is or inspecting finished dimensions more uickly and more accurately than with nap gages. R. E. Hulse of the G-E crew machine department at Schenec-ady sought and found a better method or checking groove diameters close to shoulder on a shaft. He added a lender blade and lifting lever to the lunger of a dial indicator and a simi-ar slender (1/64") blade projecting up rom the base holding the gage. The lades proved so satisfactory that use

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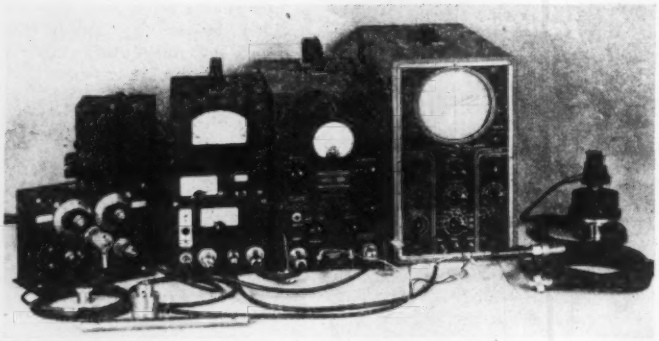

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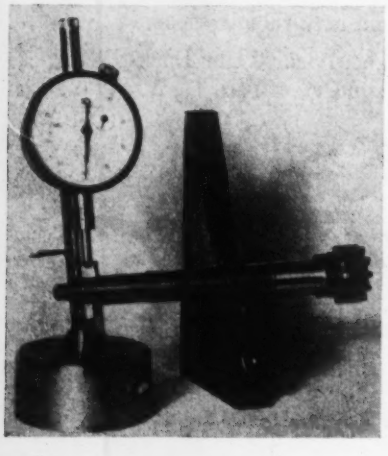

of such gages was expanded to checking both diameters and out-of-roundness of many types of shafts having a series of different diameters. (Previously, several snap gages were required for one shaft, and they would not indicate the degree of out-of-roundness.) For inspecting shafts without grooves, Mr. Hulse produced a similar attachment for a standard indicating gage, with a slender blade on only the instrument plunger. It is also possible to check classes of thread fits with these indicating gages, employing blades shaped to the thread contours. Threads can thereby be checked for taper right up to the shoulder.

Modified Micrometer. Likewise d vised at G-E's Schenectady Works, micrometer for gaging the setting boring bar cutters saves time and eli nates the guesswork involved in bri ing the cutting tool to proper positi by the usual cut and try method. T micrometer is a modification of a sta ard type with the anvil replaced by block in which a recess is ground accommodate the boring bar. A hole is drilled through the recessed p tion of the block in line with the sp dle to permit insertion of a wrench f easy adjustment of the tool in the b ing bar. To use the gage the operat first takes one cut, and thereby det mines how much more stock has to removed from the bored hole to bri it to proper size. The distance the t protrudes from the bar can be det mined readily with the gage. Then, backing off the spindle of the gage distance equal to the amount of sto to come off each side of the bored ho the tool point can be brought up to gage spindle and locked in position.

X-ray Unit Inspects 17,000 Airplane Parts Daily

CAPABLE of inspecting as many 17,000 airplane castings in a hour day, a new mass production x-r machine has been developed for a M western war plant, Westinghouse e gineers have disclosed. Key to the n unit's speed is a moving conveyor feet long and three feet wide t transports the castings through x-ray inspection and produces an e posed film of six castings every 30 s onds to provide an almost continuo flow of exposed film ready for develo ing. When developed, each film sho an inside view of the six castings. signed to inspect both engine and fu lage castings up to 5″ in thickness, mechanism has been installed at a troit plant of a large automobile man facturer producing war materials. side two steel towers, each 12 feet hi and situated near the middle of t conveyor, the actual x-ray inspection

conducted. Each tower houses an x-ray tube—one tube operating at 140,000 volts, the other at 220,000 volts—so that castings of different types and thicknesses can be examined at the same time. The castings move along the conveyor on trays that halt automatically under the x-ray tubes. A lead-lined protective device shields the operators from x-radiation while the exposure is made, and the castings then continue along the conveyor. For quickly identifying any defective castings, corresponding numbers are given the film and the castings. The unit can be operated by one man or eight men, depending upon the volume and speed of production desired. Owing to the safety factor provided by the lead-lined hoods, the unit can be located anywhere in the plant and other work can continue without interruption while the x-ray exposures are being made. Previous methods required a special lead-lined room which had to be temporarily evacuated during exposures, resulting in loss of time and efficiency.

Aircraft Relay Life Test

IN a General Electric Co. "torture chamber," where devices under development are left running until they break down, to determine length of life, Mrs. Robert Morrison is shown testing

relays for aircraft equipment. She is using a "Strobotac" [a stroboscopic tachometer manufactured by the General Radio Co.] which permits measuring the speed, in cycles-per-second or operations-per-minute, of each relay under test, without mechanical contact. Mrs. Morrison, wife of a G-E engineer, joined the Company's Aeronautics and Marine Department last year after graduating from Iowa State College and now is doing work formerly done by men engineers.

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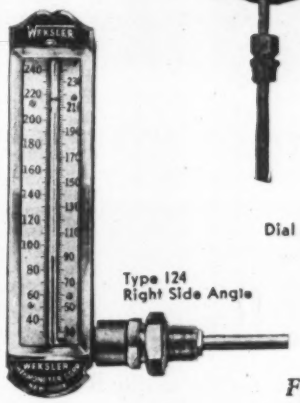
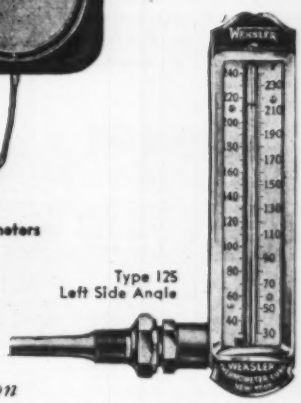


Type 124 Right Side Angle



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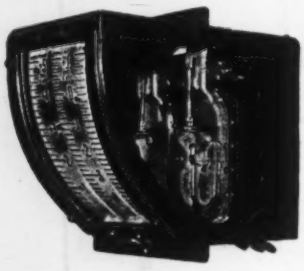

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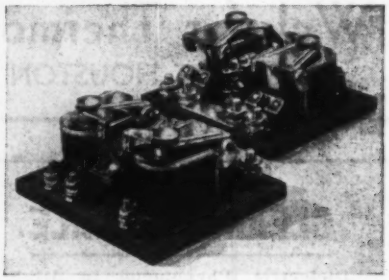
Cabin Type Thermostats

New cabin type thermostats have been designed for the control of temperature in aircraft cabins and similar compartments. Temperature-sensitive element consists of

a bimetal coil mounted on a flexing hinge. Entire operating assembly is spring-suspended on a Bakelite base and completely enclosed within an aluminum case which can be readily grounded. Rotating temperature-setting dial is visible through front of case. For applications served by dual heaters, installation is also available in a duplex model. Weight, 7 oz.; duplex type, 14 oz. Rating 0.5 amps. at 24 volts d.c.—*Barber-Colman Co., Rockford, Ill.*

Dynamic-braking Relays

New "Type 68HX100" and "Type 67HXX100" relays provide instantaneous dynamic-braking with split-series field motors. It is said that positive action, reduced weight and simpler mechanisms are thus provided for a wide range of aircraft and



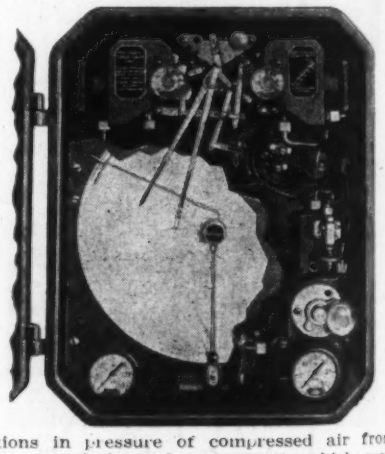
other applications: operation of retractable landing gears, wing flaps, trim tabs, bomb bay doors, hoists, etc., utilizing reversing motors. For winch operations, new relays permit substitution of a simple locking dog for conventional large magnetic brake. New relays are of Struthers-Dunn "Nutcracker-construction" in a new light-weight design said to have exceptionally strong contact pressure. There are no sliding contacts. Positive "memory" contacts select the proper field winding to give reverse torque for braking. All parts and contacts are readily accessible for inspection. New relays operate in all positions, withstand salt-spray, vibration and altitude tests. — *Struthers-Dunn, Inc., 1321 Arch St., Philadelphia, Pa.*

Solenoid-operated Shut-off Valve

New solenoid-operated fluid shut-off valve weighs only 6.96 oz., which won it Seal of Approval Certificate No. 14, Society of Aeronautical Weight Engineers. New valve has a Dural body, is equipped with standard AN 3102-8S-1P receptacle and may be had in port sizes for ⅛" pipe thread or ¼" tube fittings. Valve is normally closed. Installation may be planned for any operating position. Current 0.25 amps. 24 volts d.c. Units are available for working pressures of 50 and 250 lbs./in.². This solenoid-operated hydraulic valve was designed for the remote control of anti-icing fluid flow to various critical parts of an airplane: propellers, pilots' windshields, bombardier's windows, carburetors, and Pitot tubes. It is adaptable also for a number of other systems such as heater fuel or oil dilution control, lavatory and drinking water control in commercial transports. It is suitable also for numerous general industrial systems.—*Adel Precision Products Co., Burbank, Calif.*

Pneumatically-set Controller

New "Pneumatic Set Controller" meets demand for a dependable controller whose setting point, located by a setting-arm, would be automatically adjusted by varia-

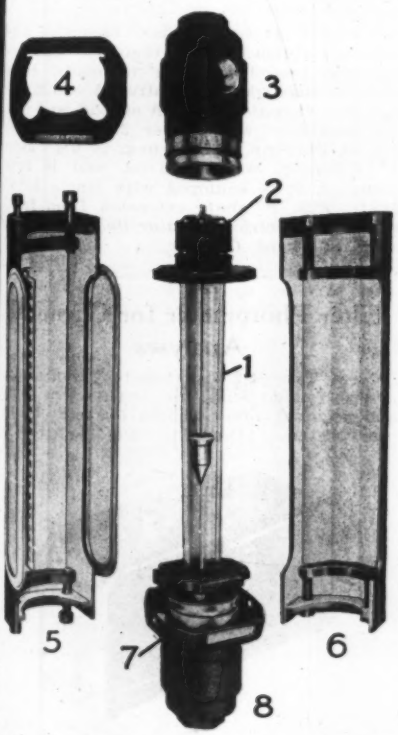


tions in pressure of compressed air from a remotely-located instrument, which may be an indicator, recorder, or controller. It is available in either the indicating or the recording form. This controller is fundamentally a "Fulscope Controller" with an additional unit to convert changes in input air pressure into linear movements of the setting-arm. Relation between input air pressure and displacement of setting-arm is governed by an adjustment dial. Unit provides also for selecting direction of setting-arm displacement for an increase in input air pressure, and for limiting the travel of the setting-arm within given limits. Setting-arm may also be set manually. "Pneumatic Set Controller" is suitable for

applications where the controlling mechanism's setting-point must be automatically and continuously reset in relation to variations in some other controlled or uncontrolled process variable: In production of synthetic rubber, to control jacket water temperature of reactors to maintain constant product temperatures. Also to control speed of internal-combustion-engine-driven air compressors to maintain constant suction or discharge pressures. In air-conditioning work, to keep a fixed temperature ratio between outdoors and indoors, thus eliminating shock experienced when there is too great a variation between the two.—*Taylor Instrument Companies, Rochester, N. Y.*

Enclosed Rotameters

New "Series 700 Master Enclosed Rotameter" is available in 18 sizes, ⅛" to 6" pipe connections, max. water capacities of 25 cc.p.m. to 825 g.p.m. and max. air capacities of 380 cc.p.m. to 1000 cf.p.m. It embodies nine basic advantages over any previous Rotameter: (1) Clean appearance: not "a pipe fitting with a glass tube in it," but an instrument engineered with appreciation of what instrument engineers want. White enamel finish on interior surfaces gives maximum illumination on float and on capacity scale. (2) Totally enclosed rigid safety construction: Steel vertical structural members 5 and 6 completely surround metering tube 1 and give load bearing surface support for end fittings all the way around. Front and back glass sight window plates are set into suitable recesses in structural members and are completely sealed off. (3) Quick opening and disassembly through use of split-ring construction: one portion of two split-rings is permanently welded into each of the two structural members near top and bottom respectively; as the structural members are slid into position



between the end fittings the split-rings slide into deep grooves cut all the way around the end fittings; locking screws prevent disengagement of rings from grooves. (4) Separate capacity scales give many

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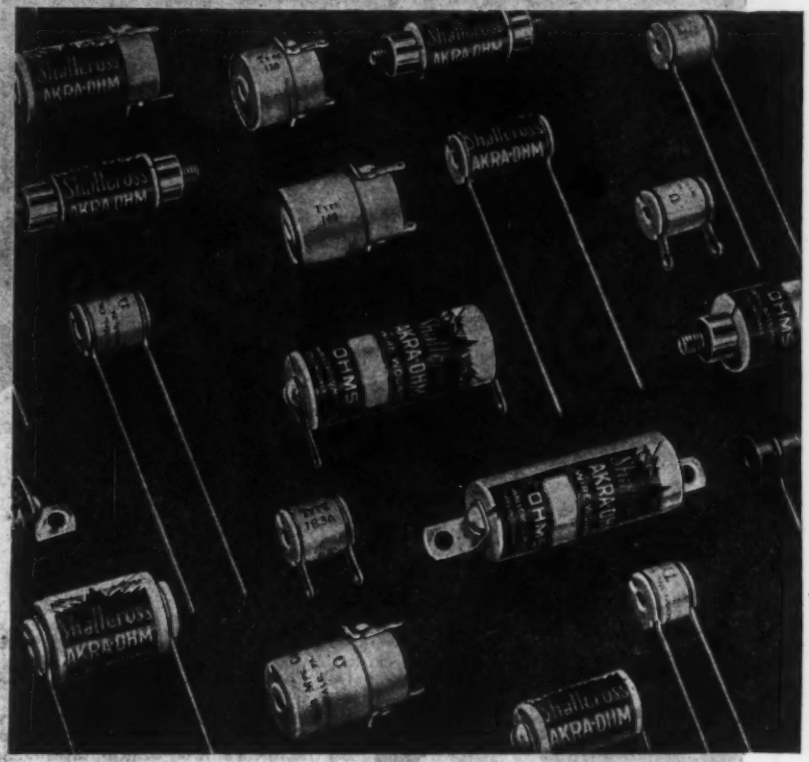

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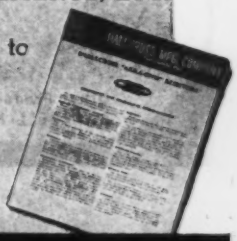

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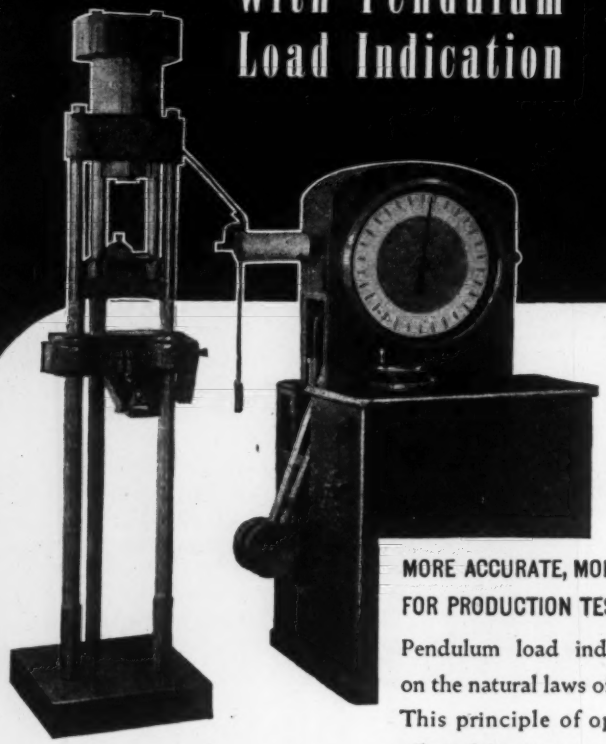

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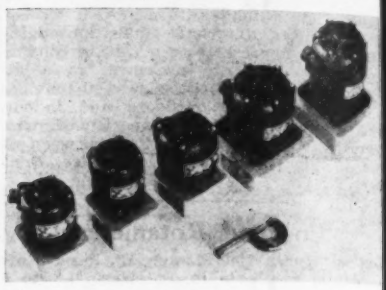
advantages and conveniences. For example, tube replacement may be made by any tube of the same size in stock in user's plant or in maker's storerooms. Visibility and readability are greatly increased. (5) Most convenient and novel special feature is provision for tightening and adjusting stuffing boxes from outside instrument. The greatest tube breakage hazard is also eliminated. Formerly a slip of the wrench frequently resulted in a broken tube; in "Series 700" it is impossible to touch the metering tube with the stuffing box wrench. (6) Universal piping connections: end pieces 3 and 8, containing the piping connections, can be rotated to any horizontal direction through a full 360° circle. (7) Tube protector ring 2 safeguards upper end of metering tube from breakage when metering float is of the "free" type and rises beyond end of tube in cases of excess flow rate. (8) Safety float stop permits float to rise freely far up past end of metering tube where it cannot be an obstruction to excess flow rates that may be required. (9) Improved instrument costs no more—and in many cases less—than previous Rotameters.—*Fischer & Porter Co., Hatboro, Pa.*

Aircraft Electric Motors

New line of "high-frequency" electric motors for use in aircraft operate on 3-phase 400-cycle a.c., can be furnished for both intermittent and continuous duty ratings, and range from ⅛ h.p. to 15 h.p. Synchronous speeds of 6,000, 8,000 and 12,000 r.p.m. can be provided, and lower speeds are available by means of integral type gear reducers. Motors are to be supplied with various types of flanges for mounting on pumps, blowers, actuators, etc. Bearings with self-contained seals are pre-packed with low-temperature grease to meet Air Corps specifications. Magnesium alloy housings and inherent weight economy of 3-phase high-frequency power result in



substantial weight saving compared to d-c equipment. Absence of commutator and brushes overcomes maintenance problems of d-c. apparatus. Windings are stationary and can be well insulated. Standard AN type connectors can be supplied. — *U. S. Electrical Motors, Inc., Los Angeles, Calif. and Milford, Conn.*

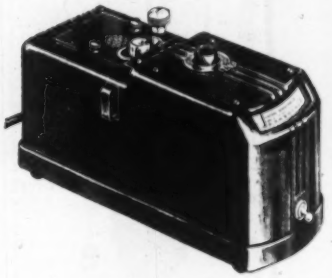
Motor-generator for A-c. Instrumentation Services

New "Model L32" motor-generator operates on 6 volts d-c. input (12, 24, or 115 volts d-c. input available). A-c. output, 1, 2, or 3 phase, varies with the speed. Stand-

ard model, housed in black enameled aluminum, includes speed regulator and resistance (speed governor optional). It is claimed that speed is controlled within 1% for 25% variation in input or load, and that the generator will deliver 27-volt 2-phase a.c. at 2400 r.p.m. New m-g. is 6¼" long, 2" diameter, weighs 32 oz. and is base mounted. It is equipped with single 5/16" shaft, with 1" shaft extension from front of case.—*Electric Indicator Co., 110 Parker Ave., Stamford, Conn.*

Filter Photometer for Chemical Analyses

New "Type B-2 Photelometer" is of smaller size for industrial use, but its sensitivity and accuracy are sufficient for most laboratory determination. The "Photelometer" is

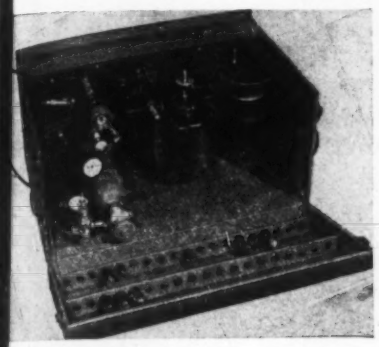


a compact filter photometer of the barrier-layer type for chemical analyses in the routine or control laboratory. Molybdenum, titanium, vanadium, or manganese in steel, lead, copper, iron or vitamins in foods are

pical determinations. Instrument is easily ndardized by determining the transmit-ncies of a number of solutions which are pared in accordance with a specific chem-l procedure. Transmittancies plotted on semi-log scale against known concentra-ns on a linear scale yield the analytical rve or standard with which unknown lutions of that technique may be com-red. Instrument comprises a low-voltage ht source, an adjustable light aperture, a olor filter holder, receptacles for tubular rectangular absorption cells, a single otocell, and a sensitive current measur-instrument with a 2½" scale. The scale ds from 0-100 in 50 divisions. A voltage nsformer to supply constant intensity of ht when operated on a controlled-fre-ency power line is furnished with the 5-volt a-c. instrument.—*Central Scientific ., 1700 Irving Park Blvd., Chicago, Ill.*

Portable Spark Plug Tester

New portable spark plug testing unit is d to be designed to "completely test and erhaul" BG, Aero, Bendix, and A.C. air-ft spark plugs in the shop or field. Cab-



et, including all necessary tools, weighs 84 s., is 26" wide, 12" deep, and 19" high. nit, operated by one ½ H.P. electric mo-r, has a hand crank for use when 110-lt power is unavailable and a hand pres-re test bomb to supplement CO_2 supply. also includes a point setter electrode ad-ster. A newly designed top, held in ver-al position by steel supports; includes two ilt-in racks capable of holding 38 spark ugs.—*Airplane Mfg. & Supply Corp., 6853 ankershim Blvd., North Hollywood, Calif.*

hotoelectric Color Comparator

New "Model 400-H Lumetron Colorime-r" is a portable self-contained instru-ent, operated by a built-in battery and quiring no power connection, therefore

uited for use in the field and where elec-ic current is not readily available. For reatest simplicity of operation, it is built s a single-filter instrument. If not speci-ed otherwise, it is furnished with a built-n filter which makes photocell response qual to human-eye color sensitivity. With his filter, instrument is suited for meas-

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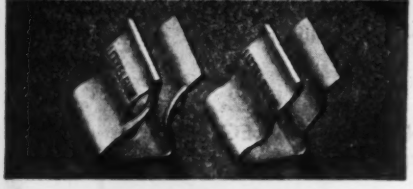

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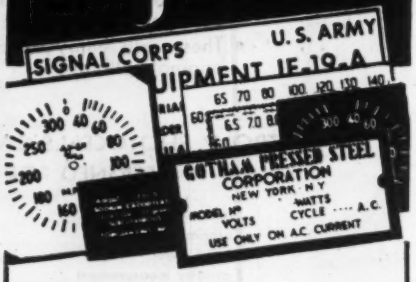

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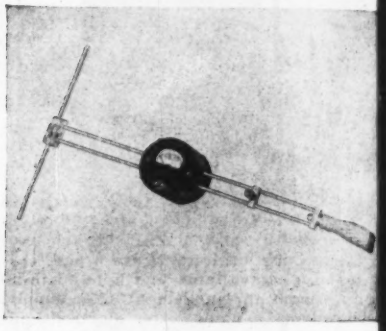
uring turbidity as well as color of solutio For limited-spectral-band applications, strument may be furnished with built color filter isolating the required band. matched glass cells and two screw-cap agent bottles are stored in a compartme This makes it unnecessary, in many stances, for operator to take along any ad tional equipment. Instrument is ready immediate use at any time, is rapid action. Results are independent of operato judgment. *Operation:* One of the glass c is filled with clear water, the other w the liquid under test. Instrument is set read 100 for cell containing water. Th other cell is inserted, and galvanometer dicates transmittance directly in perce To calibrate for a given test, a number solutions of known concentration are ma up, and their transmittances read. The readings, when plotted, furnish calibrati curve. *Galvanometer* is taut-wire type quiring no servicing unless dropped or othe wise damaged. Scale has 100 uniform gra uations. Pointer has knife-edge tip. *Gla cells* are matched standard-size test tub For faint colors or turbidities, larger ce can be used by removing a plate from strument panel. *Dimensions:* 5" × 6" × 15 —*Photovolt Corp., 95 Madison Ave., Ne York City.*

Resonance Meter

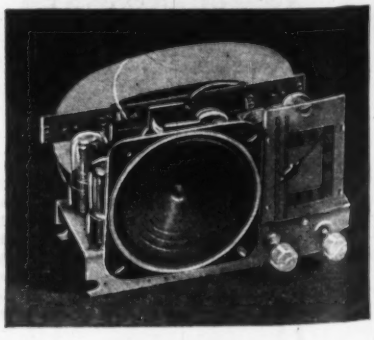
New "Erco MW-60" Resonance Meter said to meet the need for a convenien sensitive and accurate means of determi ing resonance in oscillators and transmi



ters; standing wave ratios, transmissio lines, antenna systems, tank circuits, co pling devices, and modulation indicator Ruggedly constructed, it is said to be ide for resonance measurement of transmitti equipment in the field and laboratory, suc as: absolute altimeters, blind landing mark ers, glide path markers, airport traffic co trol, weather teletype, and broadcast rela circuits. — *Erco Radio Laboratories, Inc Hempstead, N. Y.*

Radio Receiver Kit for Training Programs

New 5-tube radio receiver kit has bee developed for illustrating theory and prac tices now being covered in basic or pre-in duction radio training, permits progressiv study of rectification, filtering, detection



, i-f. and a-f. amplifications, etc. Kit sists of all necessary parts, wire, hard- re, solder, tubes, and speaker for con- uction of a 5-tube a-c.-d-c. superhet re- ver "of advanced design." Only tools ded for assembly are screwdriver, pliers d soldering iron. Circuit includes features h as oscillator-biased r-f. and i-f. stages, ntact-potential-biased audio stage, inverse dback, avc., high-capacity filtering, etc.— *ied Radio Corp., Educational Div., 833 est Jackson Blvd., Chicago 7, Ill.*

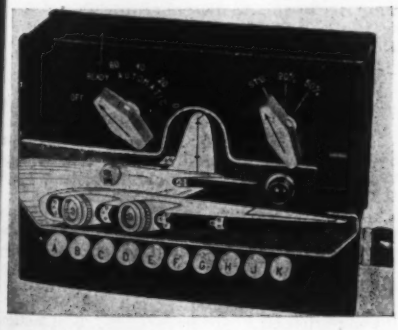
Buoyancy Type Liquid-level Indicator-controller

With announcement of new "Level-Buoy," anufacturers add to their line of auto- atic controllers a buoyancy-type instru- ent which both controls and indicates

liquid level. New instrument employs "Taylor Fulscope Control Mechanism" with either completely "Adjust- able Sensitivity" for smooth throttling level control, or "Automatic Reset" for aver- aging of liquid level with minimal disturbance to proc- ess. A torque tube transmits evel changes to instrument mechanism. his replaces stuffing box, obviates need for ubrication or packing, gives a closed sys- em which eliminates leakage. Torque tube s interchangeable with the ones used in naker's Aneroid Manometer (see *Instru- ments*, August 1942, page 327) which is an dvantage to instrument users in minimiz- ng inventories of spare parts. There are o internal pivots to cause friction or wear. he "Level-Buoy" handles liquids with spe- ific gravities between 0.2 and 2.0. It is vailable in the following standard ranges: 4", 32", 60", 72" and 120".—*Taylor In- trument Companies, Rochester, N. Y.*

De-icer Control

New "De-Icer Electronic Control" has been developed for use with maker's "Mani- fold-Solenoid De-Icer" system in conjunction with Goodrich de-icers on aircraft with



wing spans in excess of 100 feet to provide a variable control of the de-icer system to suit the rate of accretion and the texture of ice formations encountered. Complete ice removal can be effected by the de-icer meth- od despite the varying ice conditions en- countered, if the accretion of ice is per- mitted to develop a tensile strength suffi- cient to overcome the adhesion between the ice and the de-icer boot on inflation. This

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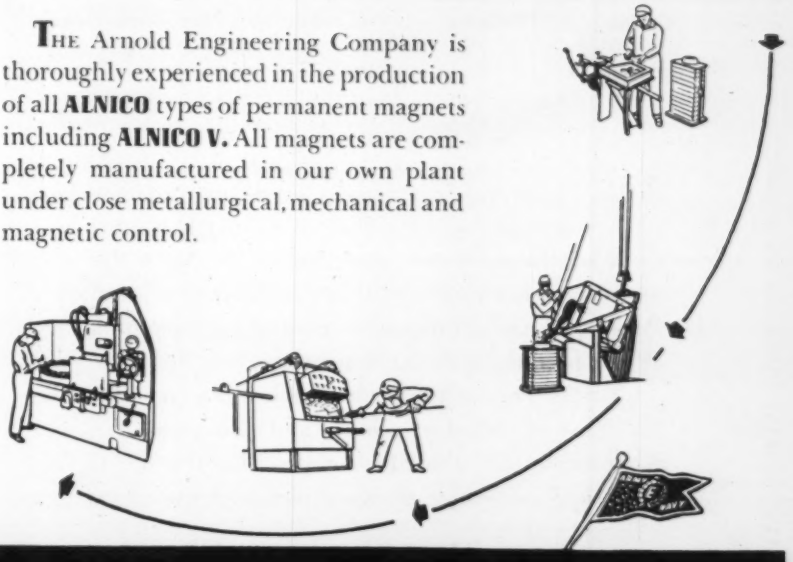
THE Arnold Engineering Company is thoroughly experienced in the production of all **ALNICO** types of permanent magnets including **ALNICO V.** All magnets are completely manufactured in our own plant under close metallurgical, mechanical and magnetic control.



THE ARNOLD ENGINEERING COMPANY
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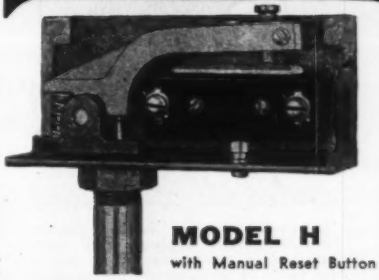
TEMPERATURE LIMIT SWITCHES



MODEL H
with Manual Reset Button

Available with switch normally closed for cutting off heat, stopping fan, closing valve —with switch normally open for lighting lamp or ringing bell—with single pole double throw switch . . . breaks heating circuit while closing alarm circuit. Sturdy, fool-proof reset button operates from outside case. Range 0-1400° F; adjustable range 200-300° F. Dimensions: 5⅛" x 1¾" x 3". Dial Pointer for easy setting.

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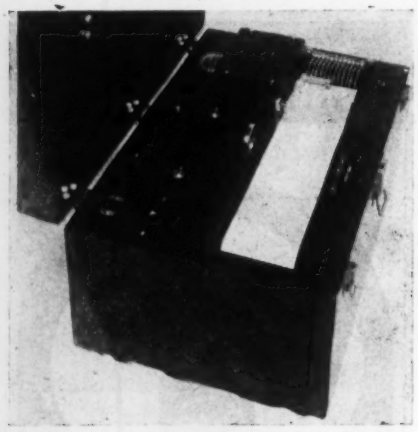

GARCEAU CHRONOGRAPH

Eleven Recording Channels
One Timing Channel

Through an inertialess electrical recording system, this Garceau Chronograph provides means of measuring without error the length of time an electric current flows. Tape can be withdrawn manually, to allow inspection of recent records, with provision for independently actuated electrical re-wind of used tape.

Tape speed is 20 centimeters per second. Timing channel prints a row of dots spaced at 1/60 second intervals.

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Holliston, Massachusetts, U. S. A.
Makers of the Garceau Electroencephalograph

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"Surco-American" high quality flexible plastic tubings and insulated wire are pretested to stand up under a wide range of temperatures and under the most severe conditions because they are specially formulated to meet the most exacting requirements. Tubings are available in inside diameters from .005". to 2". Dielectric strength averages 1500 volts per mil. thickness . . . "Surco-American" flexible plastic insulated wire is available in all lengths and colors in wire sizes #12 to #48 A.W.G. solid or stranded, shielded, tinned or silver plated copper wire and cable . . . Technical bulletins and samples on request.

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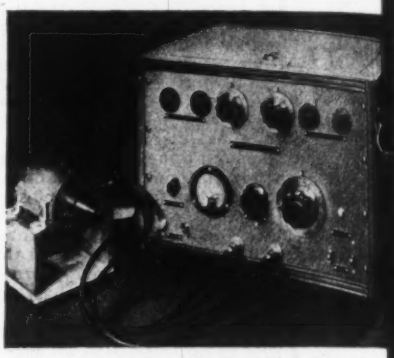
84 Purchase St. Boston, Mass.

requires that de-icer system be control for both rate of accretion and texture ice formation. New Controller accomplis this by providing a means of varying time between de-icer operating cycles compensate for variations in rate of formation and, also, varying the de-i cell inflation to compensate for variati in texture of ice formations. In addition, provides a visible automatic or manu push-button remote electrical control wing and tail de-icers. — *Eclipse-Pion Div., Bendix Aviation Corp., Teterboro, N.*

Tube Flaw Detector

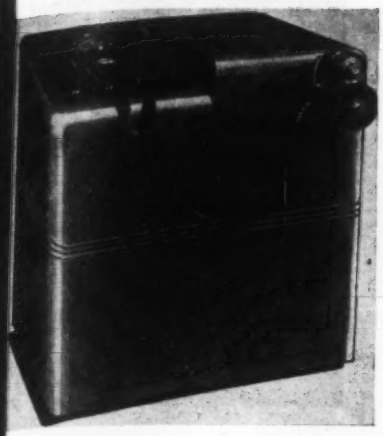
New, high-frequency eddy-current pr ciple flaw detector for production-line det tion of longitudinal cracks and seams nonmagnetic metallic tubing in an extens range of diameters and wall thicknesses, capable of detecting and locating imperfe tions ½" long, 10 mils wide, and one-thi of the wall thickness in depth, even wh they are entirely inside the metal and not appear on either surface. Instrument said to be especially desirable for testi tubing for coolers and heat exchangers b fore installation, thereby preventing fa failures in the field. It consists of a contr unit which is standard; and a coil b which accommodates any one specific si of straight round tubing of uniform outsi diameter. Additional coil boxes, (inte



changeable as to mounting, dimensions, an cable terminals) are available to accommo date any size tubing from ¼" to 2" O.D Power supply required for the electroni units is 100-125 volts, 60 cycles. *Operation* Circuit constants for particular size of tub ing are set by means of selector switche on panel of control unit. Tubing to b tested is fed through coil box. Power i applied to the coils, thereby inducing eddy currents in the tubing. A flaw in the tubing causes changes in these eddy currents. An electronic circuit in the control unit detects these changes and energizes a signal relay thus disclosing to the operator the location of the flaw.—*Special Products Div., General Electric Co., Schenectady, N. Y.*

Aircraft Starter Test Stand

New "Model 751 Amsco Starter Test Stand" is said to have simplified the operation by providing a single mounting plate for right or left direction S.A.E. 5", 6" or 7" aircraft starters. Adequate and consistently reliable starter tests are said to be obtained by torque action of starter transmitted through a two-way torque arm to a double-action hydraulic cylinder which in turn registers in foot-pounds on a maximum-registering pressure gage. Test action may be likened to that of a foot-long pendulum operated in right or left direction by the starter. At end of pendulum is a double-action hydraulic cylinder which transmits impulse pressure in either direction by direct connection to the pressure gage. Gage hand retains top pressure reading which usually indicates the "break-away" torque and allows action check on the lower-reading, clutch-slippage torque. Usual gage furnished with this tester stand allows readings



p to 2800 ft-lbs. on most aircraft starters. ther gages may be supplied. An ammeter llows check of starter motor "draw" dur- g flywheel energizing. All other neces- ary switches, including a selector switch or 12- or 24-volt operation, are on panel. ingle mounting plate is supplemented by hree adapter plates and four starter jaws. ttachment of proper adapter plate to a tarter make it readily attachable to the ounting plate ready for test after insert- g the appropriate jaw. Functionally de- igned cabinet is 38" high, 36" wide and " deep. All wiring and moving parts are ully enclosed. Either battery or rectifier odel is available, battery model contain- g a charger with tell-tale signal light on strument panel to indicate charger opera- on.—*Airplane Mfg. & Supply Corp., 6853 ankershim Blvd., North Hollywood, Calif.*

Electronic Prime-relay Unit for Automatic-control Systems

New "Flashtron" is described as "an elec- onic package unit . . . the means of bring- g about greatly improved performance in any types of automatic control setups . . .

makes it practicable to closely approach zero tolerance in regulating variables oc- curring in industrial processes, for instance pressure, temperature, liquid level, flow, speed, motion, voltage, air, fuel relation, specific gravity, gas analysis, to name a few." New unit's function is described as that of a sort of "buffer" control element operating between the sensitive primary measuring element and the power-operating (in many cases the final) control element of an automatic-control system. It is said to require negligible power for actuation and its output circuits accommodate the al- ternate energizing of loads within the range of the instrument which may be connected to it: motors for valve operation, blower fans or other motor-driven units, or other types of electrical loads such as heating elements. One of the two output circuits is always energized but both cannot be ener- gized simultaneously with contactor type actuating devices. Its dual circuit output energizing system is said to be especially suitable for the command of proportioning or positioning control elements such as valves operating from reversible motor drives. Since one or the other circuit must be in operation at any given instant, the valve will be constantly repositioned. While new "Flashtron" cannot compensate or cor- rect for lag in any of the other elements in the control system in which it is used, it does not limit full utilization of perform- ance characteristics of any of these other elements. Unit being electronic in nature, there are no mechanical moving parts, con- sequently no inertia and life of unit, it is said, should be limitless. There being no relays in its makeup, "Flashtron" is silent in operation. Unit is housed in steel box with provisions for easy connection of a 115-volt 60-cycle a-c. power line, the actu- ating circuit and the two control sections. Dimensions, 11½" × 7¼" × 3⅝".—*Thor- darson Elec. Mfg. Co., 500 W. Huron St., Chicago, Ill.*

Ingenious New Technical Methods

Presented in the hope that they will prove interesting and useful to you.

Molten Metal Sprayed on Wood Patterns Prolongs Their Life

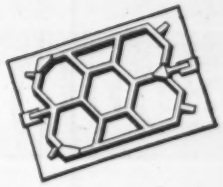
Molten metal sprayed on wood foundry patterns by a compressed air gun provides a protective coating against sand wear on the finished surfaces, thereby prolonging the life of the pattern and eliminating costly repairs.

The metal may be sprayed directly on the untreated wood surface of the pattern or core box. If the wood surfaces are hard or close-grained, a shellac primer is first ap- plied, the metal being sprayed on before the shellac dries. The thickness of the metal coating is about 5 thousandths of an inch.

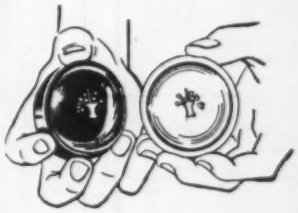
The spraying equipment consists of a portable, self-contained gun-type sprayer which melts the metal and is thermostatically controlled.

We hope this has proved interesting and useful to you, just as Wrigley's Spearmint Gum is proving useful to millions of people working everywhere for Victory.

You can get complete information about this method from Alloy-Sprayer Company, 2039 Book Building, Detroit, Michigan.



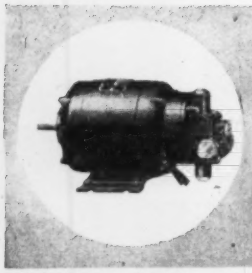
This wooden pattern coated with sprayed metal has given service far beyond its normal life.



Fine detail easily recorded in the alloy sprayed onto pattern.

Advanced Design Dual-tester

New "Model 804 Advanced Design Dual-Tester" is equipped for direct testing of all acorn tubes as well as all old and new types of regulator receiving tubes, recti- fiers, etc. It is contained in an oak case with removable cover, size 14½" × 13" × 6", weighing 12¼ lbs. It is supplied complete, ready for operation on 105-135 volts, 50-60 cycles. Among features are the "Dynop- tium" tube test circuit; double line fuses;



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The Bodine Type 12R Motor combines a motor and speed reducer in one unit. All cumbersome and complicated speed reducer transmissions are eliminated. It is compact, quiet, and attractive in appearance. This type of Bodine motor is widely used for transmitting low torques over a wide range of speeds.

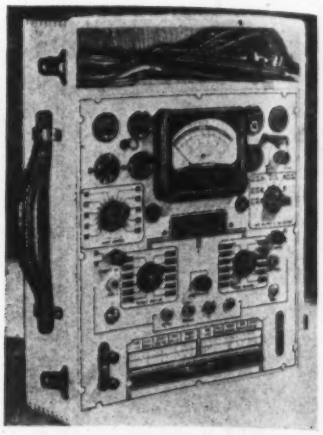
TYPICAL APPLICATION
Bodine motors provide reliable control for Zoric dry cleaning machines. Motor at lower left.

Accuracy and precision operations, required by many types of scientific and industrial motor-driven apparatus, are assured by Bodine fractional horsepower motors. Diamond-bored sleeve bearings, dynamic balancing, and many other safeguards provide accuracy and long life. The wide variety of sizes and specifications available in the Bodine line makes it possible to obtain standard-type motors engineered to each individual application. Bodine motors are available with governors, speed reducers, and other special features.

Many manufacturers have standardized on Bodine motors because they know they can depend on their quality. Bodine has been supplying industry with precision electric motors for over 35 years. Bodine Electric Company, 2244 W. Ohio Street, Chicago 12, Illinois.

BODINE

BODINE FRACTIONAL HORSEPOWER MOTORS



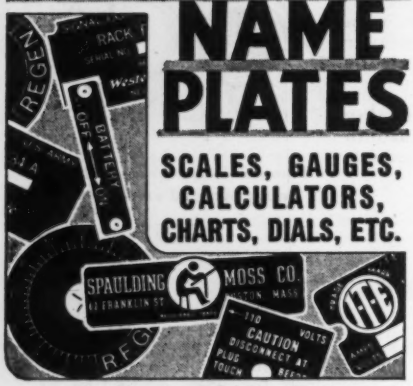
indicator protected against burn-out by i strument fuse; leakage, noise and hu tests provided; also maker's exclusive met od of a-c. measurement which is said eliminate errors inherent in copper oxi rectifier types. Ohmmeter reading ratio 500,000,000 to 1; current reading rat 1,000,000 to 1; voltage reading ratio 100,0 to 1. Latest type built-in "Rolindex" m chanical roller tube chart. Electrostat leakage tester for all mica and paper c pacitors, also an electrolytic leakage teste for electrolytic capacitors reading on "Good-Bad" Scale. A battery tester dete mines the actual condition of the batter by testing under load for various voltag ratings of batteries.—*Radio City Product Co., 127 West 26th St., New York City.*

Kelvin Bridge

In new "Model K-1" Kelvin Bridge, sour voltage is 60-cycle a.c. instead of usual d An electron-ray null indicator replaces co ventional galvanometer. Instrument can b operated by unskilled personnel at hig speeds—up to several hundred tests p hour with suitable test fixtures. Entir equipment is contained in a single cabin

requiring no outside accessories such a batteries or galvanometers. Operation reduced to utmost simplicity and directness since measurements are obtained by th rotation of a single dial directly calibrate in resistance, the dial readings being multi plied by a factor determined from the set ting of the standard resistance switch New Model K-1 is said to be particularly useful for routine measurements in pro

PLASTIC NAME PLATES



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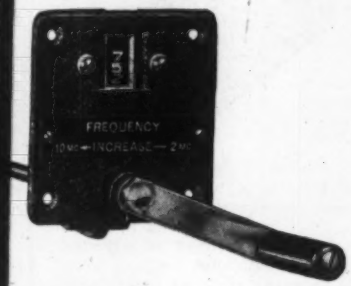
tion, or in laboratory on low-resistance ments such as fuses, fuse clips, switch tacts, etc. Source voltage being only there is no appreciable heating of any stor under test. Overall accuracy is in ±2% except for resistance values w 0.0005 ohm. Accuracy at the lowest stance that can be measured (0.0001) is within ±5%. Standard resistor de DR-20 supplied with this instru- t has 10 settings of from 0.001 to 1.0. *dustrial Instruments, Inc., 156 Culver , Jersey City, N. J.*

Cyclometer Type Counter Assembly

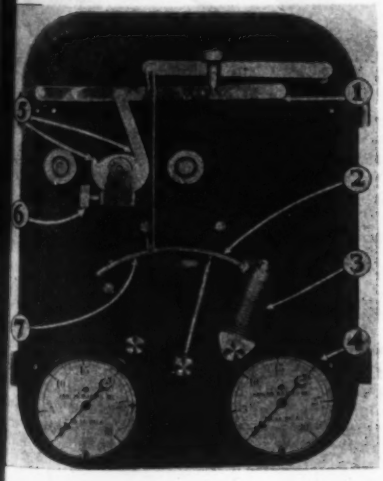
riginally designed for registering rotary turns, Cyclometer Type Counter Unit nd many additional uses and is now be- produced as a separate item. It is ptable to practically any application re a shaft must be turned a predeter-



ed number of times, or set at any pre- ermined position. It registers exact num- of turns, down to tenths of a turn. ndard counters record 10 turns. Others, o available, record up to 100-1000 turns ed with rotary coils, new counter assem- s provide a quick, easy means of set- g the contacts at any desired inductance ue. Other uses include recording vertical horizontal stabilizer adjustments on air- nes and practically any job where a ft must be rotated more than 360° and ct rotation registered. These cyclometer nter assemblies have direct shaft drive :1 drive shaft to driven unit). Shafts can any length. A Veeder-Root counter is d. Gear drive is direct, with precision steel gears. Units are light in weight oz.) and pass war-time specifications. ey are available with either right or left nd rotation, and can be supplied with me plates to suit application.—*Baker & Illiamson, 235 Fairfield Ave., Upper Darby,*

Liquid-level Controller

New "Type 1410 Level Control Pilot" has wide throttling range said to be exact in relation to the specific gravity of the



liquids handled in the system. It is recommended also for indicating or recording level service where the displacement float is used to indicate position of level in vessels where highly corrosive liquids make continuous use of gage glasses impossible. Wide throttling range settings are most important for even-flow characteristics where surge impulse elimination raises efficiency and makes for better control of the system. "Snap-action" settings are easily made without additional parts or special tools, if "on-off" action of control valve is desired. Industries where this new instrument is recommended include refining, chemical, synthetic, gasoline, recycling and power. Among features are: (1) Specific gravity index scale setting from 0.10 to 2.0. (2) Wide throttling range adjustment: from zero to 300%, setting in exact relation to specific gravity setting. (3) Long-life bellows, operating throttle arm. (4) Straight-line pilot characteristic of pressure output to diaphragm vs. level variation. (5) Simplified reversibility. (6) Adjustment for height of level control. (7) "Snap-action" settings on pilot without use of any additional parts or special tools. Other features are wide swinging door giving easy accessibility of all parts, mountable on any H-W Type 850 Displacement Level Control and equipment including H-W Type 245 Supply Medium Regulator. — *Hanlon-Waters, Inc., National Bank of Tulsa Bldg., Tulsa, Okla.*

Angle Comparator

New Angle Comparator affords rapid and highly sensitive method for comparing dihedral angles. Method was developed particularly for use in the processing of prisms for mass production work, but may also be used for comparison work of other glass or metal parts. Instrument is so constructed that it may be used with parts of various

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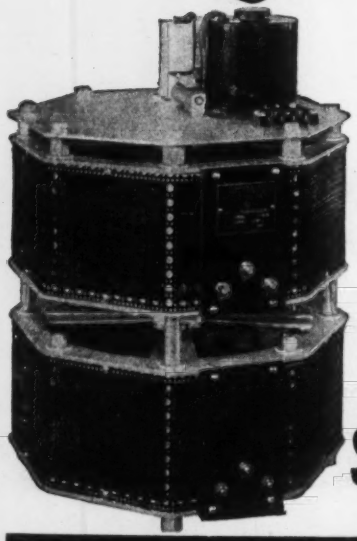

. . . for problems involving an exacting control of voltage. POWERSTATS combine the features of continuous, stepless and highly efficient control of AC voltage and power. Reliability, ruggedness, light weight, efficiency and modern design make them a standard on many types of combat equipment.

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YOU CANNOT AFFORD NOT TO OWN ONE!

Because it eliminates guesswork, waste and spoilage; it pays for itself quickly. PYRO is a *self-contained, DIRECT READING, sturdy unit* made to stand rough use but it is absolutely *accurate* and *dependable.*

Unique construction enables operator to rapidly determine temperature even on minute spots, fast moving objects, or smallest streams; no correction charts, no accessories, no maintenance expense. Special "FOUNDRY TYPE" and "Universal TRIPLE RANGE" have, in addition to standard calibrated range, a red correction scale determining TRUE SPOUT and POURING TEMPERATURES of molten iron and steel when measured in the open.

Stock ranges 1400° F. to 5000° F.

Write for Catalog No. 80

THE PYROMETER INSTRUMENT CO.
Plant & Lab.
103-107 LAFAYETTE ST., NEW YORK, N. Y.

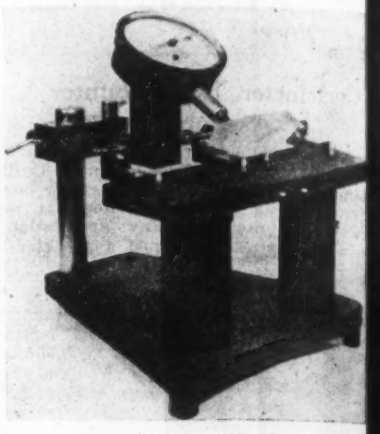
MOTOR CATALOG

Shows description, gives dimensions and output of small motors from 1/3000 h.p. to 1/3 h.p. plain and back-geared motors, for A.C., D.C., or Universal operation—dependable, efficient and economical SpeedWay Motors embodying the "know how" developed through more than 30 years of specialization in small motors—the "know how" that has answered so many war problems, for all branches of the service.

If you use small motors, write for this new catalog today. If you have small motor problems, send in your specifications for SpeedWay's recommendations.

SPEEDWAY MANUFACTURING CO., 1839 S. 52nd Ave., CICERO, ILLINOIS

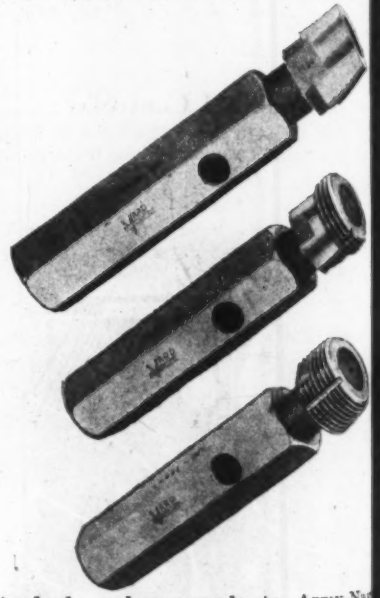
sizes, and may also be used when pris are cemented together. A simple adjustm of a few screws changes from one size another. Range of present instrument for parts whose faces are approximately square to 4" square; but instrument m be easily altered to accommodate parts smaller or larger dimensions. Instrum may be set to compare angles from 45° 135°. To set instrument for a particu



part, the three base screws and two s screws are set so as to accommodate t part. Part is then placed in instrument a dial indicator contact is adjusted so as make perpendicular contact at a point close to upper edge as possible. Perpendi larity of contact may be judged by e Contact with dial indicator is made so th when the standard part is placed in instr ment, dial makes approx. one revoluti Dial reading for the standard part may adjusted so that it is zero, but this is n a necessary adjustment. To translate sen tivity of instrument in terms of angul measure to seconds of arc, operator mak use of a table furnished with instrume —*Optical Engineering Labs. Div. of Scie tific Enterprises, Inc., 305 East 47th S New York 12, N. Y.*

Pipe Plug Gages

New pipe plug gages are said to be cha acterized by "minimum weight, maximu wear resistance and absolute accuracy They comply with American Gage Desig

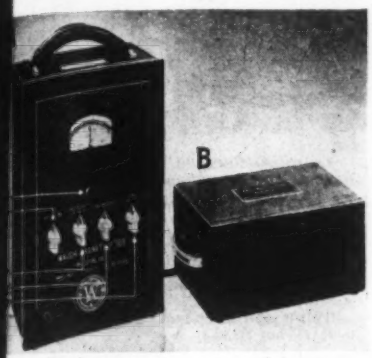


standards and are made to Army-Na specifications AN-GGG-P-363 as to type a tolerances. They may be obtained in a fu range of sizes from 1/16" to 6" pipe diam eters. They are made in three primar

es: L-1 type is a single notch working
gage for checking lead, pitch diameter,
minimum length of thread in inter-
ly threaded pipe fittings. Plain taper
type is used for checking minor diam-
and truncation of internal threads. L-3
is used to check thread form and pitch
meter of internal threads at maximum
th. These gages can be supplied in met-
or left hand threads on special order.
ster or reference pipe thread ring gages
also be supplied on order.—*Vard Inc., adena, Calif.*

Magnetometer for Materials Inspection

New "Model MW2" Magnetometer is de-
ned for use in determining the magnetic
ds produced by residual magnetism in
terials, members and parts. It measures



ld strength due to residual magnetism in
lligausses or in degrees deflection the
mber would produce on a compass. It
mprises: (A) indicating unit consisting
a stabilized, low-gain amplifier and an
ctronic bridge for indicating field strength
d polarity; (B) pick-up unit which sup-
es the controlling signal to the indicating
it. Control switches: On-off switch (b),
hen "on," energizes both the indicating
d pick-up units. Multiplier switch (c) is
ed for changing sensitivity of instrument
large steps; also serves to shut off power
the pick-up unit. Four positions are pro-
ded. Calibration control (d) adjusts the
nsitivity of the unit; is used to calibrate
e instrument for various degrees of sensi-
vity. At its extreme counter-clockwise posi-
on, this control trips a switch to a preset
libration permitting direct readings in
lligausses. Zero adjust control (e) is used
balance the electronic bridge in the in-
cating unit so that the indicator reads
ro when no input is received from the
ck-up unit. Pilot light (a) indicates when
ower is on. Equipment, after being oriented
null position in earth's field, does not
quire highly-trained technician for making
utine tests. — *Waugh Laboratories, 420 xington Ave., New York City.*

High-voltage Bakelite-cased Tubular Capacitors

New "Type '26" high-voltage capacitors
r x-ray, impulse generator and other in-
rmittent d-c. or continuous a-c. high-
oltage applications such as indoor carrier-
upler capacitors, test equipment and spe-
al laboratory work, are oil-impregnated
l-filled with Aerovox Hyvol vegetable oil.
his is said to mean smallest capacitor size
nd minimum weight consistent with safety
n high-voltage operation. Units are built
ith adequately insulated and matched sec-
ons of uniform capacitance, connected in
eries. Equal voltage stresses are main-
ained for all sections, with a uniform
oltage gradient throughout the length of
ach capacitor. High-purity aluminum foil
ith a generous number of tab connectors
rovides high conductivity with low induc-
ive reactance. Capacitor sections are dried

Protect
PILOTS AND PLANES WITH FACTS

Know what your planes must and can do... in the battlefields of the sky, over the Nation's airlines, and in performance tests.

HATHAWAY VG RECORDERS (Naca Type)•
...show you Value of acceleration at maximum airspeed; Value of airspeed at maximum acceleration; Maximum airspeed; Maximum acceleration. •Manufactured from basic designs developed by National Advisory Committee for Aeronautics.

Simple to install and operate. Weigh only 21 ounces; cost only $185.00. 4¾ inches its longest dimension!

DELIVERED FROM STOCK FOR WAR EFFORT

● THE HATHAWAY INSTRUMENT COMPANY
1315 SOUTH CLARKSON ST., DENVER, COLORADO

Hathaway INSTRUMENTS

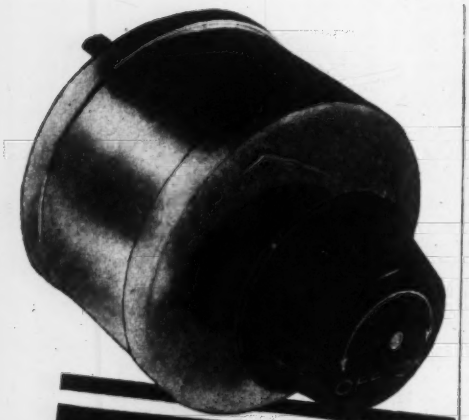
Test Insulation the Modern Way
with a MODEL B-5
MEGOHMER

VARIOUS NEW MODELS AND RANGES

NEW BATTERY-VIBRATOR TYPE
No more tiresome cranking of a hand-driven generator . . . Entirely self-contained, steady test potential of 500 volts DC, available at the touch of a switch. Direct reading in insulation resistance.

HERMAN H. STICHT CO., INC.
27 PARK PLACE NEW YORK, N. Y.

WRITE FOR BULLETIN No. 430



Enlisted for WAR

★This armored or enclosed type Clarostat power rheostat is now standard equipment in many planes, mainly for panel lighting control. Available in 25- and 50-watt sizes. Tough, both mechanically and electrically. Handles severe overloads without flinching. Minimizes maintenance. Note these features:

Insulated metal core supports resistance winding. Element imbedded in cold-setting inorganic cement. Maximum heat conduction and radiation.

Handles safely 150% of maximum current rating at settings up to ⅛ total resistance.

Since no elevated temperatures are required in processing with the cold-setting inorganic cement, wire winding remains unimpaired in production.

Tripod-type rotor provides smooth operation and positive conduction at all settings. Exceptionally rugged construction.

Standard units: 25-watt, 1 to 5000 ohms; 50-watt, 0.5 to 10,000 ohms. Other resistance values, taps, tapers, special bushings, shafts, knobs, on high-priority orders.

★ Write for bulletin on Clarostat power rheostats and other resistors, controls and resistance devices required in your work. Submit your problems.

CLAROSTAT Controls and Resistors

CLAROSTAT MFG. CO., Inc. · 285-7 N. 6th St., Brooklyn, N. Y.

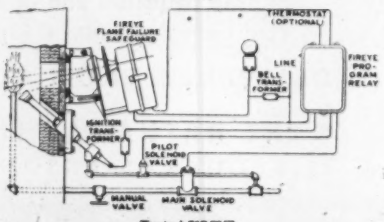
and impregnated under high vacuum in a closely-controlled long cycle. This eliminates voids and also provides for high insulation values and lower losses. Case is of special laminated Bakelite tubing protected by a high-resistance insulating varnish for high dielectric strength and maximum safety from external flashover. Long creepage path between terminals means an exceptionally conservative and safe rating for these units. Dependable operation and long service life is assured at rated voltages and ambient temperatures up to 65°C.

Terminals are two-piece cast-aluminum end caps with Bakelite-treated cork gaskets, which are locked in to provide leak-proof hermetic sealing. Caps are available with mounting feet for space-saving assemblies in series, parallel or series-parallel arrangements. Also obtainable with plain end caps. —*Aerovox Corp., New Bedford, Mass.*

Flame Failure Safeguard

New "Fireye Type F28C" photoelectric system for providing instantaneous fuel cut-off in any pressure-fed burner in event of flame failure, is capable of monitoring flame of any intensity, is applicable to oil, gas, or pulverized coal burners and is said to be "the first to operate entirely from direct observation of the flame itself rather than

FIREYE Type F28C

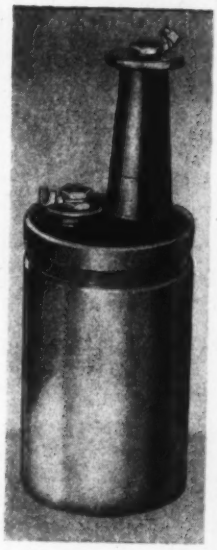


Typical FIREYE

Installation For Automatically Ignited Oil Burner

wholly or partly from such secondary flame characteristics as temperature or electrical conductivity." Being actuated by presence or absence of flame, it operates immediately and eliminates explosion hazard present when a few seconds elapse before fuel cut-off. "Type F28C" is used with manually ignited burners to cut off fuel and sound an alarm; or, when burner is automatically fired, with "Program Relay Type R25" to program fuel pump and valve operation, intermittent ignition system, purging period and recycling. Designed to operate at relatively high ambient temperatures, Type F28C is mounted directly on furnace wall (see diagram). After optical system has been aligned, field of vision of electric eye is limited to the flame itself and extraneous light is rejected. Light from the flame strikes the photocell, whose output current is amplified sufficiently to actuate a relay which operates a solenoid valve governing fuel feed, or "Program Relay Type R25" which programs entire cycle of burner operation. Should flame fail, or any condition impairing safe operation develop within the electronic control, "Fireye" cuts off fuel supply. — *Combustion Control Corp., 77 Broadway, Cambridge 42, Mass.*

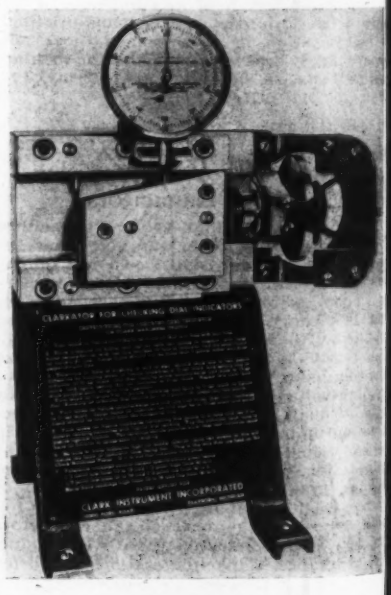
High-altitude Oil Capacitors



New high-al tude oil capacito for aircraft equ ment builders, w developed throu extensive tests a studies of termi breakdown volta in rarefied atm pheres. One of th capacitors is sim lar to standa "Aerovox Type '1 round-can barri cap units, exce that one termin is a short scr post; the other h a tall insulator po with corona shie sembly is a on piece ceramic ca with can top sp at top. Cover s over a rubber ga ket and cap f hermetic seal. A rangement of te minals, coron shield and ceram cap minimizes surface leakage, corona loss and probability of voltage breakdowns ev at extreme altitudes. For impregnant a fill, this aircraft Type '12 capacitor utiliz "Aerovox Hyvol" vegetable oil which is sa to have the desirable characteristic of mai taining effective capacitance even at su zero temperatures—an important factor high-flying applications. — *Aerovox Cor New Bedford, Mass.*

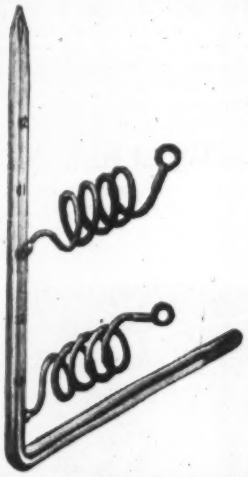
Dial-indicator Calibrator

New "Clarkator," for checking accura of dial indicators, employs the sine b principle, checking against the tangent the angle. Indicator to be tested is mount as shown in illustration, with its spind resting on a lapped angle block, which advanced or retracted by a screw. Aft clamping indicator in position so that i zero reading coincides with the dial face the Clarkator, the screw is revolved either direction to check other indicat readings. Reading of Clarkator dial is b means of a mirror, enabling it to be see together with the indicator. The Clarkat is said to be suitable for receiving an periodic inspection of standard direct-read ing indicators and of the reversed-readin indicator used on Rockwell hardness tes ers. Front angle is used when checkin standard indicators, each revolution of th



For Extremely Close Temperature Control

Visual-Stats



● Sensitivity of a hundredth of a degree is easily attainable. ● Top of mercury column visible at control point (where most important) because electrodes terminate at back of tube. No encircling metal bands! ● Available in angle form (illustrated) or conventional straight form. ● Send for brief, attractive bulletin.

The Philadelphia Thermometer Co.
915 Filbert Street -:- Philadelphia

Oldest Thermometer Manufacturer in Philadelphia

Interval Timers

Process Timers

Signal Timers

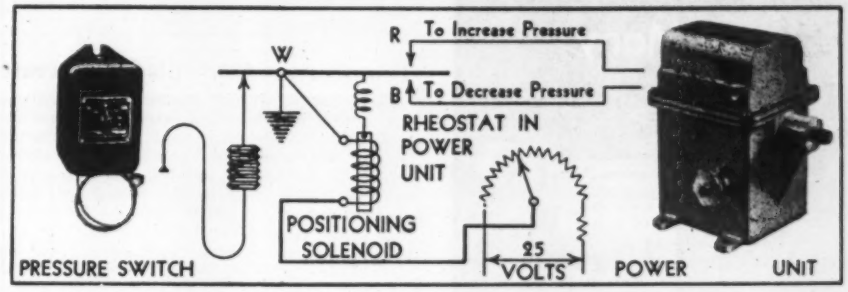
Time Switches

Relays

Write

AUTOMATIC ELECTRIC MANUFACTURING CO.
MANKATO, MINNESOTA

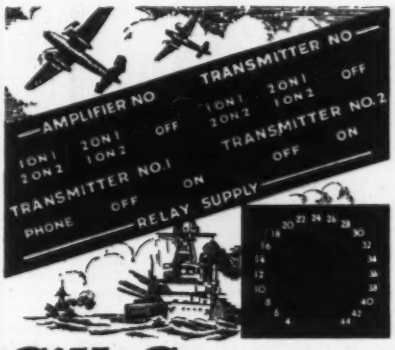
BARBER-COLMAN PRESSURE SWITCH



MICRO SYSTEM GIVES FULL PROPORTIONING CONTROL...

The pressure-sensitive bellows operates a switch to control the power unit. In the power unit a potential dividing rheostat, keyed to the driving shaft, changes the pull of a solenoid until the switch opens when the power unit reaches the desired new position. Extremely accurate control, with elimination of "hunting", is achieved. No current or potential-sensitive relays are required. Maximum power is available at every point of the stroke. The heavy duty rheostat is enclosed in the motor case with constant pressure on the contact arm to assure dependable operation at all times. The "droop" or proportioning range is variable. This system will provide reliable, accurate, micro-control of pressures uniformly over its full range. Write for Bulletin F1917 giving further details.

BARBER-COLMAN COMPANY 1202 ROCK STREET ROCKFORD, ILLINOIS



Silk Screens for WAR work!

A *proved*, ECONOMICAL method, in use by various war industries for reproducing DIALS, GAUGE, PANEL and INSTRUMENT markings, lettering, graduations, designs.

NO MACHINERY REQUIRED. Highly satisfactory for quantities from 10 to 10,000 impressions.

Send us copy, drawing or blueprint for estimate on complete screen and full details.

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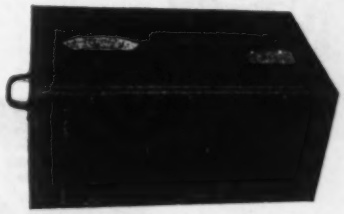
CHRONOSCOPE



Measures Time Intervals
1 to 200 Milliseconds
1% Accuracy

Inquiries Invited

Dynamometers, wattmeters, milliammeters and voltmeters. Also ultra-sensitive meters both for A.C. & D.C., fluxmeters, electrostatic voltmeters from full scale 120 volts to over 20,000 volts, thermocouples, earth current meters, cable testers, etc.

Special Apparatus Built to Order

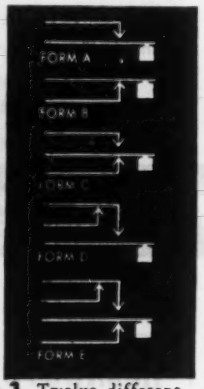
RAWSON ELECTRICAL INSTRUMENT COMPANY
110 Potter St. Cambridge, Mass.
New York, N. Y.; Chicago, Ill.

This CLARE Relay Can Take the Place of Many

Clare Type C d.c. Relay

■**This rugged multiple-contact relay permits innumerable contact arrangements. Permits designing to small size, with a lesser number of relays; and facilitates maintenance. Adapted for use in electronic control devices and for sequence control and interlocking operations. Ideal where unusual arrangements of relay control are desired. Here are the reasons why:**

1. Contact springs employing any of the forms illustrated can be furnished.

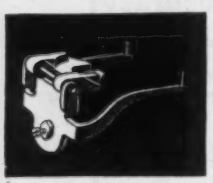


2. Spring pile-up insulators of heat treated Bakelite which permit punching without cracks, have minimum cold flow and low moisture absorption content. Assembly locked together under hydraulic pressure. Withstands heavy breakdown tests.

3. Twelve different standard or special types and sizes of contacts can be furnished. Contacts are overall-welded to nickel silver springs. Sizes range from .062" silver, rated one ampere, 50 watts, to .1875" tungsten, rated four amperes, 500 watts.

4. Spring bushing insulators are Bakelite rod made by a patent process. Strong, hard, long wearing. Essential where heavy contact pressures are employed, where vibration exists, or heavy duty service is desired.

5. Armature assembly single or double arm. Has stainless steel shaft, operating in a marine brass yoke. Heel piece, coil core and armature are magnetic metal carefully annealed. Designed for d.c. service.



6. As illustrated, relay has octal base plug mounting for easy service and replacement. Other mountings, and Bakelite or metal cover, can be supplied.

• • •

This relay is an example of Clare "custom-built" design and construction. Clare engineers can "custom build" a relay to meet your specific requirements—one that will reduce your overall relay cost and simplify your design problem. Write for catalog and data book. C. P. Clare and Co., 4719 West Sunnyside Avenue, Chicago.

CLARE RELAYS

"CUSTOM-BUILT" Multiple Contact Relays for Electrical, Electronic and Industrial Use

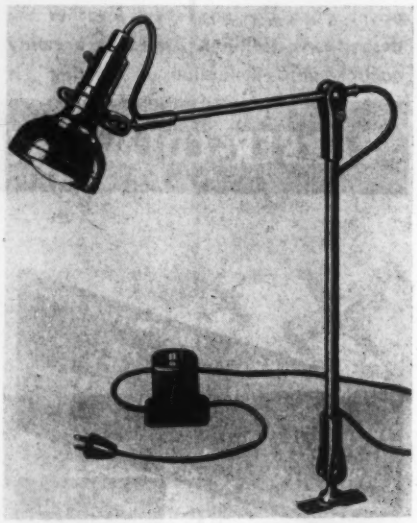
screw equalling 0.020", and each point on the dial 0.0002". Back angle provides a direct method of checking hardness tester indicators, each revolution of the screw equalling 0.01962". Complete directions are included with the instrument.—*Clark Instrument Inc., 10200 Ford Road, Dearborn, Mich.*

Temperature Controls for Aircraft

New line of "hi-g" temperature controls, for operating flaps on airplanes, operate hydraulically and are said to be designed to give instant automatic response on either liquid or air-cooled motors. They are said to have been thoroughly tested on both commercial and combat planes. It is said that these new controls further reduce the human element in plane operations, that all advantages of the "hi-g" line have been retained, and that positive operation is assured in any position, regardless of vibration, change of motion or acceleration. Designed primarily for warplanes, new units offer equal advantages to manufacturers of post-war aircraft.—*General Controls Co., Glendale, Calif.*

Supplemental Lighting Fixture

New "Diehl-Lite" for inspection, assembly and sorting, precision machine work, etc., is provided with a blue-tinted lens that gives non-glare daylight beam illumination,



with maximum intensity over area where light is most needed. Additional crystal clear or ruby red lenses are available for special uses. Light unit, in Bakelite housing, is mounted on an adjustable tubular steel supporting arm with three ball-and-socket joints. Long life and resistance to shock are said to be assured through use of a special 6-8 volt lamp with patented brass contacts conveniently located toggle switch. Standard equipment includes 110-volt or 220-volt transformer, approved oil-resistant wiring and attachment plug.—*Diehl Mfg. Co., Finderne Plant, Somerville, N. J.*

Pulsation Damper

New "Type 1106 Ashcroft Pulsation Dampener" is described as "a small, compact, and effective throttling device, ideal for use with pressure gages subject to severe pressure pulsations and rapid fluctuations, such as on reciprocating pumps." It is good for all pressures up to 5000 lbs./in^2 and for any pressure medium such as air, water, oil or steam. By preventing excessive or harmful pointer vibration, it saves wear on gage movement, saves time in reading true mean pressure, helps keep gage in calibration and prolongs gage life. *Principle:* A small Monel plunger oscillates freely in a cylindrical hole in the bushing. Clearance between plunger and hole is sufficient to give proper throttling ac for certain conditions. Free movement plunger makes device self-cleaning. S no throttling device is effective under conditions (such as scope and rapidity pressure fluctuations, and viscosity of p sure medium), five different size holes provided in bushing. Plunger may easily transferred from one hole to another, pending upon degree of damping requi All holes are sealed off except the one use, by means of sealing disk.—*Ashc Gauge Div., Manning, Maxwell & Mo Inc., Bridgeport, Conn.*

Serological Bath Cover

New gable-type polystyrene cover USAMC Se ological Bath has the advant over former copper cover in being tra parent as well as resistant to corros

Moreover, its low coefficient of heat trans makes it an excellent thermal insulator assist in maintaining constant temperat inside water bath. When these covers w put to use, it was observed that conden moisture abruptly ran down to edges dropped into water bath, instead of dr ping onto the test tubes as would oc with former metal covers.—*Precision Sci tific Co., 1750 N. Springfield Ave., Chic 47, Ill.*

PROTECT YOUR HOME FRO TUBERCULOSIS

BUY and USE Christmas Seals

Post War Clock Movements

by

CHELSEA

Our production of special clock movements and clockwork mechanisms for recording instruments must wait until this war is won. Meanwhile, we would welcome the opportunity of working with you in developing your post-war designs.

Remember, Chelsea has been making special movements for recording instruments for many years.

Let's continue to back the attack!

CHELSEA
CLOCK COMPANY
385 EVERETT AVENUE
CHELSEA 50, MASS.

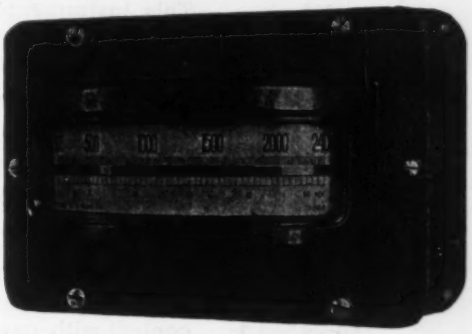
WHAT do you need in a PYROMETER ?

SENSITIVITY RESISTANCE
DURABILITY SIMPLICITY

Engelhard Direct Deflection Indicators have all these features . . . Accurate sensitivity to the most minute voltage variations due to suspension type construction . . . High resistance per millivolt and no appreciable error when used with thermocouples of different resistances and on connecting leads of considerable length . . . Sturdy construction, adapted to use under severe conditions without danger . . . So simple that instant readings may be made directly in either millivolts or temperatures by someone unfamiliar with the principles of pyrometry . . . On kilns or furnace installations, where "spot readings" are desirable—the Engelhard Rotary Switch permits separate readings from many points.

Write for Catalog

PORTABLE MODEL P-1



WALL TYPE W-1

CHARLES ENGELHARD, INCORPORATED
90 CHESTNUT ST. NEWARK, NEW JERSEY

HARDNESS TESTING...

done WITH NO MENTAL HAZARDS. The SCLEROSCOPE has done it for the past 36 years.

In general use for specification purposes. Simple, sturdy. Comparatively inexpensive.

•

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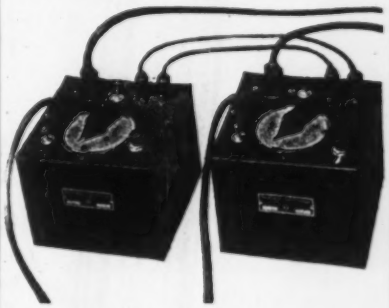
Affords unique advantages—at low cost

CADILLAC GLASS CO.
900 WEST CERMAK ROAD
CHICAGO, ILL.

PHOTOVOLT ELECTRONIC TIMER

An adjustable timing relay operating without clockwork or motor.

- **High speed timing, from 1/20 sec. up.**
- **Immediate automatic resetting**
- **Push button and remote control**



Any number of standard units can be combined for

Sequence Timing and Recycling

in continuous operation.

For

Production and Process Control
Welding, Printing, Signaling
Laboratory Use and Life Tests

Write for literature

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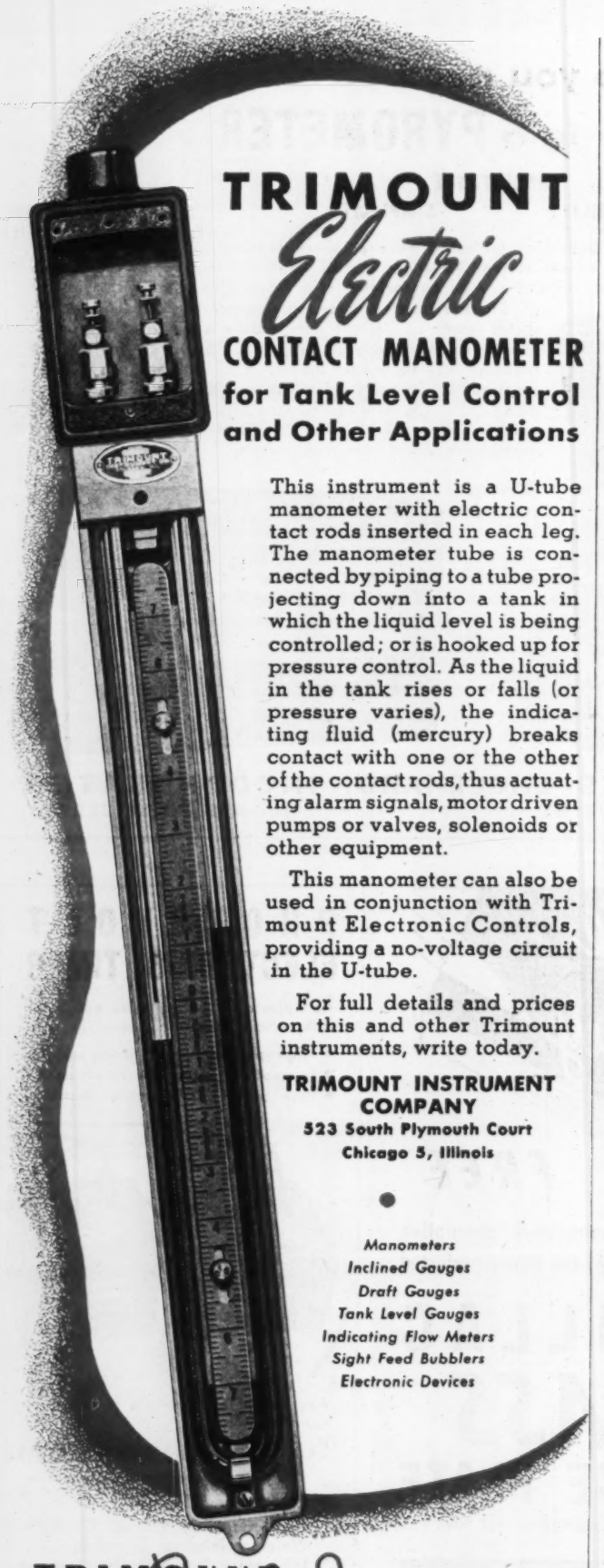
95 Madison Ave. New York City



TRIMOUNT *Electric* CONTACT MANOMETER

for Tank Level Control and Other Applications

This instrument is a U-tube manometer with electric contact rods inserted in each leg. The manometer tube is connected by piping to a tube projecting down into a tank in which the liquid level is being controlled; or is hooked up for pressure control. As the liquid in the tank rises or falls (or pressure varies), the indicating fluid (mercury) breaks contact with one or the other of the contact rods, thus actuating alarm signals, motor driven pumps or valves, solenoids or other equipment.

This manometer can also be used in conjunction with Trimount Electronic Controls, providing a no-voltage circuit in the U-tube.

For full details and prices on this and other Trimount instruments, write today.

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MANOMETERS

Electron Tubes

Concluded from page 667

The exact manner in which this is accomplished will described later, but first it will be of advantage to consid briefly, what happens at that part of the cycle where voltage passes through zero, i.e., at the point where the charge through the tube stops.

As was shown in the preceding chapter the reason grid loses control of the plate current once the plate curr is established is because of the presence of a large numb of positive ions in the space between the cathode and anode. These ions neutralize the negative space charge.

Ionization and Deionization Times

As the anode voltage decreases, the production of th ions decreases and finally there comes a time when the r of ion generation can no longer be maintained and the (for the discharge through the tube is really an arc) sto At this instant, the positive ions combine with the near existing free electrons to form neutral atoms of whate gas may be present in the tube. The grid can regain cont of the tube just as soon as the positive ions have been moved from the space around the grid. The length of ti required for these ions to be removed (i.e., for their reco bination with electrons to form neutral atoms) and the grid to regain control is called the "deionization tim This time varies from about ten to several hundred mic seconds. This time varies directly with the gas pressure a inversely with the negative grid and anode voltage.

The formation of the arc discharge also requires a defin length of time, the "ionization time," required for the io to reach all parts of the discharge path. The ionization ti (usually much smaller than the deionization time) decrea with an increase in voltage or gas pressure.

The ionization and deionization times are important the application of tubes for various frequencies since th impose limiting conditions with respect to the use of t tube on higher frequencies. A condition can easily be i agined, of course, in which the frequency is so high that ionization cannot take place between successive positive ha cycles and under this condition the tube would be usele either as a rectifier or for other control purposes.

For our purpose here it will be sufficient to keep in mi merely the "starting" voltage and assume that the "extin tion" voltage is somewhere close to zero. In the two-eleme gaseous tube, the starting voltage and the extinction vo age are nearly the same. In the three-element tube, ho ever, they are not the same—the thyratron owes its gre versatility to the grid's ability to make the starting volta vastly greater than the extinction voltage.

Another point: In our consideration of the tube here, t grid has been operated under a negative potential. As h been mentioned before, however, this is not an essential r quirement and tubes may be divided roughly into two class according to their characteristics. One class includes the called "positive tubes." In these the discharge will not sta until the grid has been made positive with respect to t cathode. The other class contains the "negative tubes" whi are designed so that the discharge will start unless t grid is maintained a definite amount negative with respe to the cathode.

These differences in characteristics are obtained by var ing the construction and spacing of the elements in the tub The characteristics displayed by the positive-grid type tube are obtained by making the shielding due to the gr so effective that the plate voltage has practically no effe on the potential in the neighborhood of the cathode. T electron current leaving the cathode is, therefore, ind pendent of the plate voltage. In the negative grid tubes, t shielding is not as effective and the electron current leavi the cathode is not independent of the plate voltage.

So much for the fundamental action of the tube. In th chapter only the basic principles involved in the contr function of the thyratron have been explained. The manne in which the controlling potential is applied to the grid exactly the right time will be explained in a subsequen chapter.

Dynamics

Concluded from page 663

ogram weight act vertically downwards and the torque ll be

$$Q = mgl \cos \phi$$

ere l is the length of the crank arm and ϕ the angle ich the crank arm makes with the horizontal.

Demonstration of the Second Law of Motion of Rotation

(a) In Fig. 11 are shown two hubs of front wheels of cycles. Atached to each hub are six spokes or rods about " in diameter and whose lengths are about 15". On each oke is a sliding mass of about 1 pound each. These asses may be slid along the spokes and by means of set rews fixed at any point along the spoke. The masses of e two wheels are identical. On the outer end of the hub each wheel is attached a wooden drum, D, about 2" wide d 5" in diameter. The diameter of the hub itself is about ". If a string is wound about the hub or about the drum, e have at our disposal two different torques applied to set e wheel in rotation when a given mass M is attached to e free end of the cord.

This torque is Mgr for the hub where r is the radius of e hub; and MgR is the torque when R is the radius of the um. When our two torques are now related to the moment inertia of the wheel and its angular acceleration, we e that

$$Mgr = I\alpha_1 = Q_1$$
$$\text{and } MgR = I\alpha_2 = Q_2$$
$$\text{so that } \frac{\alpha_1}{\alpha_2} = \frac{r}{R}$$

This simply states that the angular accelerations of the heel will be directly as the radii of the drums on which e cord is wound when the same mass is attached to that rd.

Demonstration of the Properties of Rotational Inertia

(b) This same equipment just described, Fig. 11, may be sed in demonstrating how the property I (moment of ertia or laziness to change of angular velocity) may be aried. As stated above, the masses of the two wheels in ig. 11 are the same and would behave identically if just

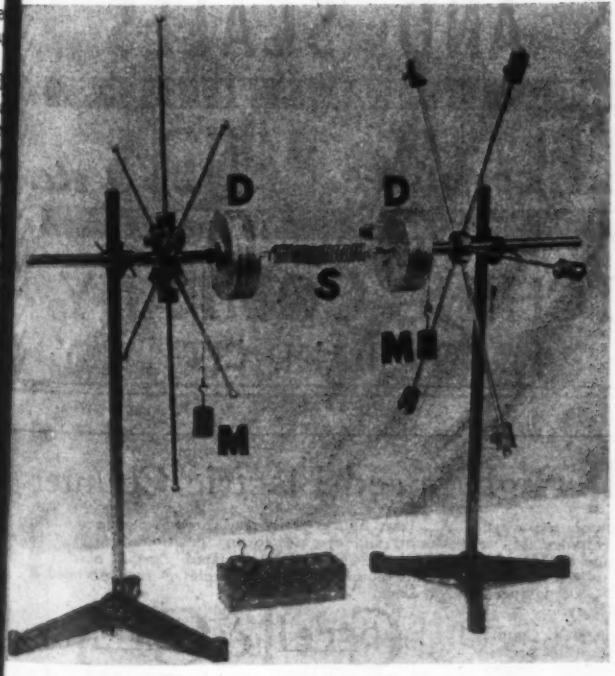

Fig. 11. Apparatus for demonstrating torques, the effect of distribution of mass in rotatory motion and the third law of motion of rotation.

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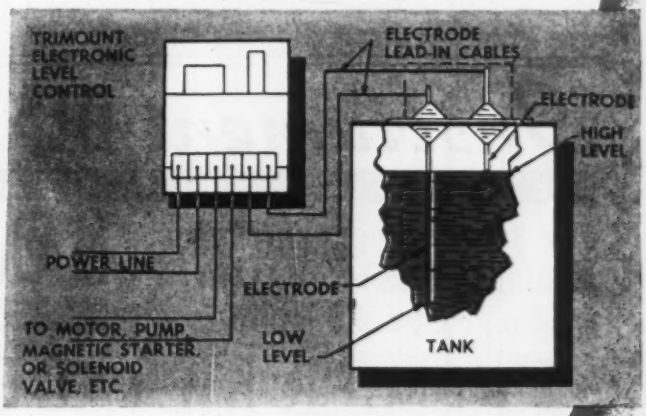

Diagrammatic sketch, Trimount Electronic Level Control with two electrodes in open tank.

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DEVICES

thrown in a straight line. Their linear inertia would be the same. When it comes to rotation, however, we see that the rotational inertia is a function of the distribution of the mass about the axis of rotation.

Wrap the string about the 5″ drum and attach a kilogram mass to the free end. In the first instance clamp all of the sliding masses as near the axis of rotation as possible. When the torque MgR is now allowed to act, the wh will be accelerated. Note carefully the angular speed builds up. Now slide the movable masses out to the ou ends of the spokes and again let the same torque opera on the wheel. This time it will be observed that the spe builds up much more slowly because of the greatly enlarg moment of inertia, for the moment of inertia is measur by the product of M and r^2 where r in this case means t average distance the mass of the wheel is from the a rotation. $I = KMr^2$. For smoothness in the running of o automobiles we try to put as much of the mass of the f wheel in the rim as we can put there and yet give streng to the part which holds the rim to the center.

Law 3. Action and Reaction are equal. To every torq action there is an equal and opposite torque action. In Fi 7 a torque had to be applied. This was the force, F, exert by the wheels of the engine at a distance of about 1 from the axis of rotation. $I\alpha$, the product of the mome of inertia of track and the angular acceleration imparted the track, is the value of the opposing torque action, hen $Q = Fr = I\alpha$.

Demonstration of the Third Law of Motion of Rotation

Connect the two wheels as shown in Fig. 11 by means a spiral spring, S, and then turn one wheel until an adde twist is in the spiral spring. On releasing both whee simultaneously one wheel will start in one direction a the other in an opposite direction. Action and reaction a equal. This still holds when one wheel has its sliding mass near the axis of rotation and the other has them near t outer ends of the spokes. The twisted spring is analogou to the expanding gases in the exploded powder when drives the bullet in one direction and the rifle in the othe The twist in the spring drives one wheel clockwise and t other counterclockwise, but one cannot act without t other. Action and reaction are equal. This demonstration analogous to the one shown in Fig. 5 in which the two car are accelerated linearly either by a stretched or a com pressed spring.

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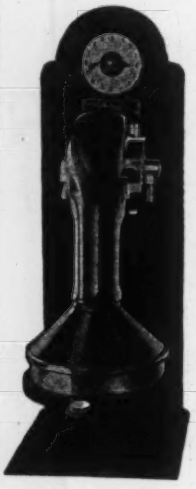

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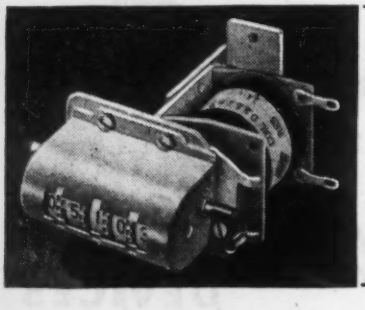

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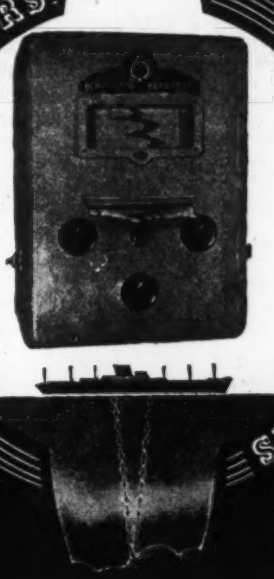

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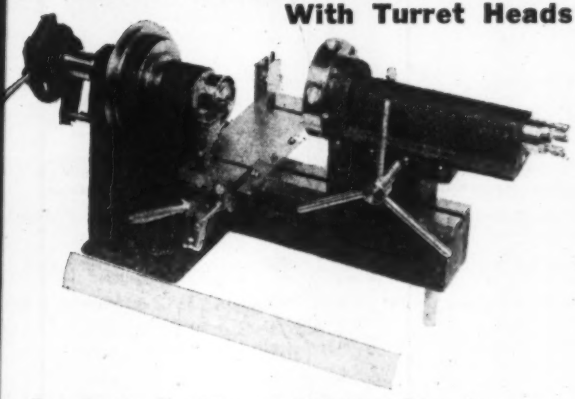

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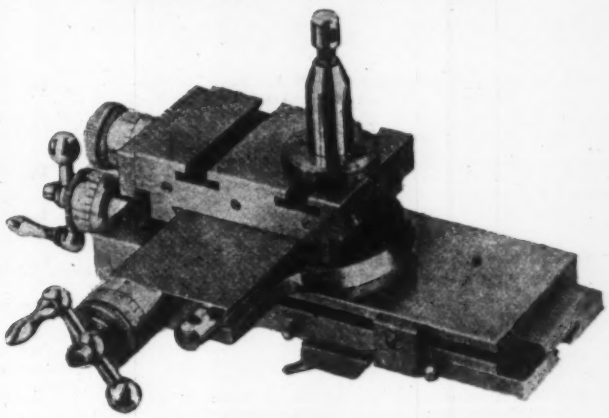

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Instrument Societies

BALTIMORE

Thirty-four members and guests attended the October 15, 1943 dinner of the Baltimore Industrial Instrumentation Society at the Longfellow Hotel, Baltimore, Md.

The technical session which followed the dinner was addressed by Mr. J. S. Detwiler, Taylor Instrument Companies, whose subject was "Air-operated Instrumentation of Process Industries." He used a number of slides to illustrate his points on the air operated type of control. A very lively question period followed his lecture.

—CARL B. WILLNECKER

CHICAGO

The second meeting of the current season of the Chicago Society for Measurement and Control was held on Monday evening, October 4, at the Graemere Hotel. The speaker of the evening was Mr. O. F. Mingay, Radio Manager of the Directorate of Radio and Signal Supplies for the Australian Government.

The speaker offered an unusually interesting talk, which while it deviated considerably from instruments, it was associated with this subject in a general way. Again stress was laid on the necessity of furnishing reliable equipment to the Armed Forces.

The climax of the evening was reached when moving pictures of Australia were shown, as well as some actual motion pictures of naval and air engagements.

—J. A. RIGGS

GULF COAST

A group of instrument men in the Gulf Coast Area met at Lamar College, November 3, 1943, and formed the "Gulf Co Instrument Maintenance Men's Associati

The objects of the Association will be educate its members by the following:

1. Pursuing a definite course of study regular meetings.
2. Arranging for the presentation of pers by specialists in refinery pract
3. Arranging for lectures by represen tives of various Instrument Compan

T. H. Pierson was elected Tempor Chairman.

The next meeting will be held Novem 22, 1943 in the Vocational Building Lamar College, Beaumont, Texas.

All Instrument Men in the Gulf Co Area are urged to attend.

Continued on next po

INSTRUMENT SOCIETIES CALENDAR

City	Society and Secretary		Date	Place	Subject	Speaker
Atlanta	Georgia Society for Measurement & Control	J. E. Eaton, 425 Peachtree St. N.E., Atlanta	Nov. 22(A)	Blue Flame Room, Atlanta Gas light Co.	Water Conditioning for Boiler Feed	J. E. Fearon, Boiler Equip't Service Co.
Baltimore	Baltimore Industrial Instrumentation Society	C. B. Willnecker, 6732 Danville Ave., Dundalk, Md.	Nov. 19(D)	Maryland Academy of Sciences	The WPB's Activity in the Instrument Field	H. P. Rockwell, Jr., Elec. Ins. Sec., WPB
			Dec. 17(D)	Maryland Academy of Sciences	Rayotube Pyrometry	H. L. Pfaffhausen, Leeds & Northrup Co.
Chicago	Chicago Society for Measurement & Control	Carl Hope, 2626 W. 31st Blvd., Chicago	Dec. 6(B)	Phil Smidt, 1170 Indianapolis Blvd, Roby, Ind.	Instrument Maintenance in an Oil Refinery	B. A. Hiermeier, Sales Mgr., Brown Inst. Co.
			Jan. 3	To be announced	Automatic Control in Boiler Plants and in Processes	R. A. Ackley, Republic Flow Meters Co.
			Feb. 7	To be announced	Liquid Level Control	To be announced
			Mar. 6	To be announced	Furnaces with Controlled Atmospheres	N. K. Koebel, Lindberg Eng. Co.
Gulf Coast	Gulf Coast Instrument Maintenance Men's Ass'n	T. H. Pierson, 3030 Roberts St., Beaumont, Tex.				
Hartford	Hartford Society for Measurement & Control	Stephen J. Zelle, Whitney Chain & Mfg. Co., Hartford, Conn.				
Newark	New Jersey Society for Measurement & Control	N. E. Chance, 14 Glen Oakes Ave., Summit, N. J.	Dec. 7(B)	Essex House	"Information Please"	Panel of "Experts" from our members
New York	New York Society for Measurement & Control	R. K. Farnham, 545 Fifth Ave., N. Y. C.				
N. Indiana	Northern Indiana Soc. Measurement & Control	R. W. Schreiner, 4 Waltham St. Calumet City, Ill.	Dec. 10(C)	Wicker Park Restaurant, Hammond	Pressure Reducing and Regulating Valves	G. R. Thomason, Mason-Neilan Co.
			Jan. 14	To be announced	Installation and Application of Flowmeters	L. K. Spink, Foxboro Co.
			Feb. 11	To be announced	Oil Refinery Instrumentation	O. G. Kaasa, Sinclair Ref. Co.
			Mar. 10	To be announced	Dev. of Perm. Magnet and Applications	C. A. Maynard, Indiana Steel Products Co.
			Apr. 14	To be announced	Film: "Approved by Underwriters."	
Philadelphia	Philadelphia Society for Instrumentation	George Hammer, 712 Otis Bldg., Phila. Pa.	Dec. 17(B)	Engineers Club	Telemetering	Perry Borden, Bristol Co.
Pittsburgh	American Society for Measurement & Control	L. M. Susany, c/o Carnegie Institute, 4400 Forbes St., Pgh.	Nov. 22(B)	Roosevelt Hotel	Oxygen Instruments	Wm. Wildhack, Natl. Bureau of Standards
			Dec. 27(B)	Roosevelt Hotel	The Rotameter and its Secrets	Kermit Fischer, Pres. Fischer & Porter
			Jan. 24(B)	Roosevelt Hotel	Graphical Method of Process Analysis	J. G. Ziegler, Taylor Instrument Co's
			Feb. 28(B)	Roosevelt Hotel	Automatic Temperature Control	C. O. Fairchild, C. J. Tagliabue Mfg. Co.
			Mar. 27(B)	Roosevelt Hotel	Principles of Automatic Temperature Control	J. C. Peters, Leeds & Northrup Co.
St. Louis	St. Louis Society for Instrumentation	Gus Holubeck, Union Electric Co.				
Toronto	Canadian Society for Measurement & Control	T. C. Agnew, Minneapolis-Honeywell Reg. Co., Toronto	Nov. 18(B)	Chez Paree, 220 Bloor St. W., Toronto	Control Instrumentation in Process Industries	Ralph Clarridge, Taylor Instr. Co's

(A)Meeting at 7:30, no dinner. (B)Dinner at 6:30, meeting at 8. (C)Dinner at 7, meeting at 8. (D)Meeting at 2, no dinner.

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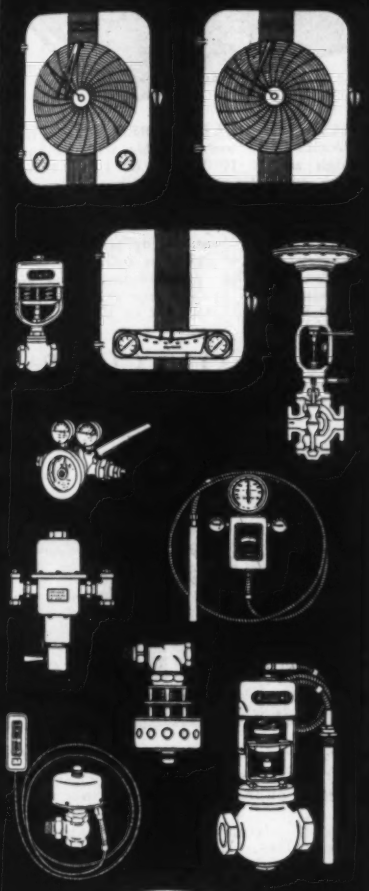

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NEWARK

The regular November meeting of the Society for Measurement and Control (New Jersey) was held the second Tuesday in November (November 9th) instead of the regular first Tuesday, which was Election Day.

Mr. W. B. Heinz, Consulting Development Engineer, representing The Cochrane Corporation, of Philadelphia, talked on "Application of Control Instruments to Industrial Processes."

Mr. Heinz covered in complete detail the various component characteristics of controllers and the different influencing factors encountered in Control Application in Industrial Processes. He defined and illustrated the ideal characteristics of a controller valve combination for pH control, specifically, and defined and illustrated what was meant by "Controller Load," "Process Lag," "Process Dead-Time," etc.

The discussion which followed was limited because of the thorough manner in which Mr. Heinz covered his subject.

—N. E. CHANCE, *Acting Secretary.*

PHILADELPHIA

The October 20 meeting of the Philadelphia Society for Instrumentation broke all attendance records with 114 present to hear Mr. Moore talk on "Pneumatic Null Balance System Applied to Industrial Instruments."

With slide illustrations, he very nicely covered the subject, starting with the common balance as a fundamental and its pivot as the only possible frictional error. Then duplicating the system by Pneumatic Balance, following through with various innovations of this system, involving a booster pilot, he described the operation of the amplifying system, differential, level, motion, and temperature transmission units.

To top it off, the "Nullmatic" Control Units for Proportional, Reset, and Rate Response, which were shown were unique in design and operation, in that they were not built with levers or bearings.

An interesting discussion period followed.

—GEORGE HAMMER

[Received too late for October issue]

THE AUSTRALIAN SOCIETY OF INSTRUMENT TECHNOLOGY
93 William Street,
MELBOURNE.

To inaugurate the activities of the Society a meeting will be held late in November. The Society is making special arrangements for this meeting, which will be attended by the Presidents of the various engineering and technical institutes and societies in Melbourne. A comfortable lecture hall has been booked and a first class supper will be provided.

In view of the importance of the occasion in the life of the Society it was felt that an outstanding speaker should be chosen to address the meeting, and we are fortunate in having Professor Kerr Grant, of the University of Adelaide, in this capacity. The title of his address is "Instruments: Their place in an industrialised society."

Professor Kerr Grant is always worth listening to, and is himself keenly interested in the practical applications of the subject. He is particularly well fitted for our purpose, because he has an exceptional insight into what industry wants from science.

The meeting will not deal with business matters, and the policy of the Society is to start punctually at 8 p.m. and devote the evening to matters of real interest.

After the address discussion and questions will be welcomed.

Admission will be by invitation only, and members wishing to attend should notify the Honorary Secretary, or telephone Miss Dawson, MU 4816.

—P. A. CRIVELLI, *Honorary Secretary*

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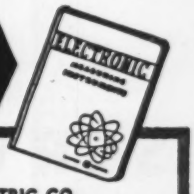

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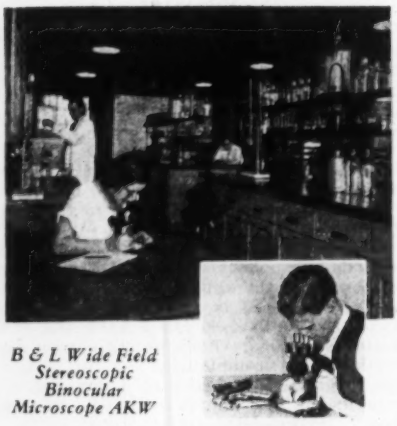

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Manufacturers' New Literature

In this department we report ALL pieces of new literature pertaining to Instrumenta received from the manufacturers. To assist in the War Effort we urge readers to request ON those bulletins which will be of value to them. Use the coupon on the facing page.

K-333 **Pressure Control.** Bulletin 100, 8½" × 11", 16 pages, describes completely the application of Askania regulator equipment to pressure and flow problems. Installation photos and diagrams show how the equipment is used. One of the features of the bulletin is the valve sizing chart. This chart, being published for the first time, shows how butterfly valve sizes may be determined in a quick and easy manner. Askania Regulator Co., 1603 S. Michigan Ave., Chicago 16, Ill.

K-334 **High Speed Mass Production Tester.** Folder, 8½" × 11", 6 pages, a new folder dealing with the Rotobridge Automatic High Speed Mass Production Circuit Tester. Offers interesting facts to makers of all types of electronic equipment. Bulletin describes how the Rotobridge detects trouble and errors automatically and swiftly. The Rotobridge tests a circuit a second and checks circuit resistance values as low as .001 ohms, with Wheatstone bridge precision. Easily operated by inexperienced workers. The tester requires but one set up, maintains specified tolerance and so releases skilled labor for other work. Communication Measurements Laboratory, 116-118 Greenwich Street, New York, N. Y.

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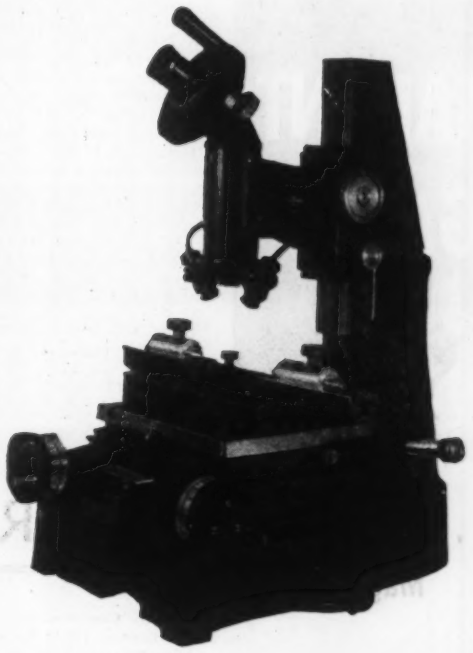

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